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Reuse of Chemical Fiber Plant Wastewater and Cooling Water Blowdown

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*Micro screening,

27 Abstract Waste waters from a Fortrel Polyester manufacturing plant consisted of organic chemical process wastes, cooling system blowdown, and sanitary wastes from the plant. A water reuse program was instituted which consisted of : (1) pretreatment of cooling waters for removal of heavy metals; (2) in-plant modifications and additions to the existing system to increase treatment plant capacity; and (3) a post treatment system for effluent polishing prior to selected reuse. The final system consisted of : (1) a chromate reduction unit rated at 120 gpm for concentrations of up to 300 mg/l $CrO_4^{=}$ and designed for continuous operation; (2) equalization basins having a combined capacity of 195,000 gallons and containing sufficient mixing capacity to prevent short-circuiting and stratification; (3) a plastic media roughing filter consisting of two tiers of poly-vinyl chloride media 10 feet thick and 25 ft in diameter; (4) an aeration basin equipped with 175 hp of aeration and mixing capacity and using 100% recycle of clarifier sludge; (5) a peripheral flow type clarifier; (6) two series connected polishing ponds; (7) a micro screen or algae screen ; (8) a flocculant and/or carbon unit; (9) a sludge pond; and (10) a digester. Chromium was removed from the cooling tower blowdown for $.21 per pound of chromate removed. The plastic media trickling filter, used as a roughing filter, provided 40% BOD removal over a wide range of loading rates. The 0.33 mgd industrial and domestic waste water was treated and reused at a rate of 0.10 mgd for approximately 40¢/1000 gallons. (Lowry-Texas)

Abstractor Mark V. Lowry | Institution Texas Univ, Austin

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REUSE OF

CHEMICAL FIBER PLANT

WASTEWATER AND COOLING WATER BLOWDOWN

BY

FIBER INDUSTRIES, INCORPORATED
CHARLOTTE, NORTH CAROLINA 28201

DAVIS & FLOYD ENGINEERS, INC.
GREENWOOD, SOUTH CAROLINA 29646

FOR THE

ENVIRONMENTAL PROTECTION AGENCY
WATER QUALITY OFFICE

PROGRAM NO. 12090 EUX
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OCTOBER 1970

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This report has been reviewed by the Water Quality Office of the Environmental Protection Agency and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency.

ABSTRACT

Demonstration studies were conducted to determine the feasibility of reusing industrial and domestic wastewaters from a FORTREL Polyester manufacturing plant. The wastewaters consisted of organic chemical process wastes, cooling system blowdown and domestic wastewaters from the plant. Selected unit processes and operations were superimposed on an existing activated sludge system in an effort to improve the quality of the treated discharge. The cooling system blowdown was pretreated with sulfur dioxide in an acidic environment to remove the chromium. The cooling water biocides which passed through the chromium reduction unit were observed for their possible effect on the biological treatment system. A plastic media trickling filter was evaluated for its effectiveness as a roughing filter ahead of an activated sludge unit. The effluent from the secondary treatment system was filtered through a microscreen, and treated with polymers and/or carbon to remove color, COD, dissolved and suspended solids.

The results of these studies indicate that chromium can be removed from the cooling tower blowdown for 21¢ per pound of chromate and that the type and concentration of biocides normally used in cooling water are either destroyed in the chromate reduction system or exhibit no adverse effect on the secondary and tertiary treatment system. The plastic media trickling filter, operated with a sludge recycle from the clarifier and reduced the BOD by 40%. The 0.33 mgd industrial and domestic wastewater can be treated and reused at a rate of 0.10 mgd for approximately 40¢/1000 gals.

This report was submitted in fulfillment of project 12090 EUX under partial sponsorship of the Federal Water Quality Administration.

Key Words: Cooling Water, Chromium, Chemical Reduction, Chemical Precipitation, Trickling Filters, Filtration, Tertiary Treatment, Water Reuse.

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SECTION I

RESULTS AND CONCLUSIONS

Many conclusions can be drawn from the evaluation of each of the various research and development units installed in the treatment plant as a part of this grant. These conclusions are presented on a unit by unit basis as they pertain to the grant.

Chromate Reduction Unit

1. It has been demonstrated that the removal of hexavalent chromium from cooling tower blowdown can be accomplished by chemical reduction and precipitation utilizing sulfur dioxide in an acidic media followed by neutralization and settling.

2. The biocides which are normally used in cooling water systems and which may be contained in the effluent from the reduction unit are accounted for as follows:

   a. Sodium pentachlorophenate when used as a biocide in cooling water will pass through the chromate reduction unit and enter the waste water treatment plant. It has no adverse effect on the plant and does not appear in the effluent from the clarifier.

   b. Methylene bis thiocyanate is similar to sodium pentachlorophenate in that it passes through the chromate system and enters the waste treatment plant. It has no adverse effect on the plant and does not appear in the clarifier effluent.

   c. 1, 3 dichloro -5, 5-dimethylhydantoin is not stable within the cooling system and dissipates within six hours of introduction. It has not been detected in the cooling tower blowdown.

   d. N-alkyl dimethyl benzyl ammonium chloride is destroyed in the reduction process and therefore is not a problem in the waste treatment plant.

   e. Sodium dimethyl thiocarbamate and disodium ethylene bisthiocarbamate are destroyed in the chromate reduction process and therefore have no effect on the waste treatment plant.

Plastic Media Trickling Filter

3. Chemical and sanitary wastes generated in the production of FORTREL Polyester can be treated using a tower packed with plastic media. BOD_5 reductions in the range of 40 percent have been attained using a single tower and utilizing sludge recycle from the clarifier.

4. The percent reduction in BOD_5 appears to be constant at approximately 40 percent over a loading range of 300 to 950 pounds BOD_5 per 1000 cubic feet of media per day using a sludge recycle mode. With no sludge recycle the percent BOD_5 reduction tends to be constant at 25 percent over a loading range of 300 to 700 pounds per 100 cubic feet of media per day.

5. The percent reduction of BOD_5 at these loadings is not significantly changed by variations in hydraulic loadings ranging from 0.95 to 6.75 gallons per square foot per minute.

6. Recycle rates up to 5:1 appear to have minor and insignificant effect upon BOD_5 percent reduction. At ratios ranging from 5:1 up to 9:1 there appears to be a five percent improvement in the BOD_5 reduction. It must be concluded that increasing recycling ratios in these ranges has no significant effect on BOD_5 reduction.

7. Sludge recycle over the tower, together with sanitary and chemical waste, results in a net BOD_5 reduction increase of a nominal 10 percent as compared to no sludge recycle under the same conditions.

8. A comparison of the treatment of waste water from the manufacture of polyester utilizing plastic media as a roughing filter versus mechanical aeration indicates that costs of construction for equivalent treatment capacities are equal. Therefore the two systems must be compared and selected on a basis other than cost.

9. Plastic media trickling filters will freeze and become inoperative at ambient temperatures of $10^{o}F$. (waste influent temperature $45^{o}F$.)

Microscreens and Chemical Treatment Unit

10. It has been observed that the microscreen (algae screen) performed well in warm weather but tended to become clogged with slime growth during periods corresponding to algae blooms in the ponds. In winter the spray nozzles froze when the ambient temperature dropped below freezing.

11. Polishing pond effluent waters can be chemically treated to achieve water suitable for reuse as cooling tower make-up. The cost for chemicals for such treatment is as low as $0.08, per 1000 gallons of water treated. This is typical for the many flocculants and carbons evaluated.

12. Clarifier effluent waters can be chemically treated to achieve water suitable for reuse as cooling tower make-up. The cost for chemicals for this treatment is $0.11 per 1000 gallons.

13. The BOD_5 reduction and the COD reduction for the secondary treatment system was in excess of 95% during the grant period.

14. Sludge disposal from the secondary treatment system as well as spent powdered carbon from the tertiary system and screenings from the microscreen were lagooned. This is considered to be the ultimate disposal of the sludge. When the lagoon is full another will be established and the present one will be covered with dirt.

SECTION II

RECOMMENDATIONS

The conclusions presented in this report are the basis on which these recommendations are made. It should be noted that they are based on a minimum of one years full scale operation of the various treatment units.

1. No recommendations are made for further study of the chromate reduction unit. The design and operation were satisfactory and the unit is now in permanent use. The potential for chromium pollution of the receiving stream from deliberate cooling tower blowdown has been removed. A system of this type is recommended for use at other installations having similar cooling water blowdown problems.

2. It is recommended that the cooling water blowdown with heavy metals removed and containing the type and concentration of biocides evaluated in this study and normally used in such cooling systems be treated in activated sludge waste water treatment plants.

3. It is recommended that studies be instituted to develop an oxidation-reduction potential (ORP) probe that will operate under the conditions encountered with this cooling water for longer periods of time without loss of sensitivity.

4. The use of a plastic media trickling filter for polyester waste is recommended as a roughing filter ahead of an activated sludge waste water treatment system when additional treatment capacity is needed and when space for construction of a treatment facility is at a premium. The use of the plastic media is not recommended in areas where it will be placed in the open and where ambient temperatures below freezing occur as the unit may freeze and become inoperative. (Waste water temperatures must be considered since they may over rule the ambient temperature effect.)

5. It is recommended that studies be undertaken to determine the effects of commonly used biocides and dispersants in shock load concentrations on activated sludge systems. This type information would be valuable for overcoming the effects of spills.

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6. The installation of a microscreen between a polishing pond and a chemical treatment unit is recommended. This unit serves the primary purpose of removing algae clumps and mats and other macroscopic debris and by so doing protects the chemical treatment system.

7. The reuse of chemically treated polishing pond effluent is recommended over the reuse of chemically treated clarifier effluent as cooling water makeup since the former is less effected by treatment plant upsets and also has less phosphates and nitrates in the final treated water.

8. Studies centered around the reuse of polishing pond effluent for recreational purposes is recommended. Such data is available for effluent from the treatment of municipal wastes, but is lacking for industrial waste.

9. It is recommended that the treatment system be operated on a production basis using chromate reduction, equalization, roughing filter, mechanical aeration, clarification, polishing ponds, algae screens, polymer addition and final filter at an estimated cost of operation of 40¢/1000 gallons.

SECTION III

INTRODUCTION

Background

The Fiber Industries, Incorporated, FORTREL Polyester plant at Shelby, North Carolina, has been in operation since 1960. The initial manufacturing plant was small and the sanitary and industrial wastes were treated in an Imhoff Tank. As the FORTREL Polyester plant grew, the waste water treatment facility expanded and changed until in 1968 it consisted of a very large and modern extended aeration activated sludge system and final polishing lagoons.

In parallel with the growth of the FORTREL plant there was a general awakening of interest in pollution abatement technology throughout the country. Fiber Industries, Incorporated, recognizing the potential for reusing effluent as cooling tower makeup, retained Davis & Floyd Engineers, Inc. to perform a reuse feasibility study. When this study indicated an apparent gap between desire and technology, application was made to the United States Department of the Interior, Federal Water Quality Administration for a Research and Development Grant. The proposed project was to include pre-treatment of the cooling water to remove heavy metals, in-plant modifications and additions to the treatment plant to increase the treatment capacity, and finally a post treatment system to polish the effluent prior to selected reuse.

Fiber Industries, Incorporated was awarded Research and Development Grant 12090 EUX by the Federal Water Quality Administration early in 1968. The project was basically a water reuse project utilizing the existing activated sludge waste treatment plant onto which the various grant units to be studied were superimposed.

The project was funded on April 4, 1968. Construction started early in August. The first unit of the grant was placed in operation in December 1968, and by February 1969 all units were in operation. The plant was operated under the terms of the grant until June 4, 1970 at which time the operational phase was completed.

SECTION IV

RESEARCH AND DEVELOPMENT PROJECT

APPROACH

Effluent from the existing waste water treatment facility, as mentioned previously was of high quality. Specifically, the BOD_5 was generally less than 25 mg/l, the COD was less than 300 mg/l, and the dissolved solids were in the range of 500 mg/l. Dissolved oxygen and suspended solids content varied continuously as a result of an ever changing quantity of algae growth in the polishing lagoons. Thus, in order to reuse this water, facilities for handling obvious quality deficiencies and/or waste treatment problems which could arise had to be installed.

Suspended solids, primarily algae growths, and dissolved nutrient materials had to be removed or reduced in quantity so that cooling tower sludge and slime problems would not be unduly aggravated. After consideration of various alternatives, microscreening followed by powdered carbon-chemical coagulant-dual media filtration processing was selected to pretreat effluent waters before their reuse in the tower.

Dissolved solids in the effluent water were known to be much higher, 500 mg/l as compared to 100 mg/l, than in the potable water normally used for cooling tower makeup. It was expected, therefore, that blowdown from the tower would be increased markedly. Increased blowdown added two new requisites; namely, a facility for handling tower system treatment chemicals; i.e., chromates and biocides and a facility for handling increased biological loads from organic contaminants; e.g., ethylene glycol.

A review of industrial practices revealed that chromates could be effectively separated from an aqueous stream by chemically reducing the hexavalent chromium to its trivalent form and then precipitating the trivalent chromium as chromium hydroxide. A process using sulfur dioxide as the reducing agent and sodium hydroxide as the precipitating alkali was chosen because of the greater ease of handling and immediate availability of these chemicals.

A plastic media trickling filter was selected to supply the added biological treatment capacity required to handle increased tower blowdown. This selection, which followed review of various potential treatment processes, was made primarily because promixing data appearing in the literature indicated substantial cost savings over other methods. Space and arrangement features also permitted

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relatively quick evaluation of this equipment's efficiency when used as a roughing treatment preceding the existing activated sludge unit.

Scope and Objectives

The objectives of this research and development project were "to treat synthetic fiber manufacturing waste and cooling water blowdown by such methods as chemical reduction, sedimentation, plastic media trickling filters, polishing ponds, algae microscreening, carbon absorption and/or organic polymer flocculation, such that the treated waters can be reused as a process water makeup stream".

In order to accomplish this, a general plan for the grant was adopted as follows:

1. Install a chromium reduction system in the cooling tower blowdown system which will remove hexavalent chromium from the waste stream and evaluate the various biocides which are used to control biological growth in cooling towers to determine if they can be introduced into the waste treatment systems without significantly reducing or changing the treatment capability of the system.

2. Install a plastic media trickling filter in the treatment plant influent stream and evaluate the following:

   a. BOD_5 and hydraulic loadings and recirculation rates for the treatment of waste water from polyester fiber manufacture.

   b. The efficiency and economics of using plastic media as compared to mechanical aeration for waste water treatment as it pertains to this particular plant.

   c. The efficiency of land usage for waste water treatment systems utilizing plastic media as compared to mechanical aeration for waste water treatment.

3. Install a final treatment system consisting of a micro-screen (algae screen), and a powdered carbon and flocculant treatment system in the effluent stream to accomplish the following objectives:

   a. Demonstrate that a chemical fiber waste which has been pretreated in a waste treatment plant can be post-treated by screening and/or activated carbon and/or flocculants and reduce the color, BOD, COD and total solids to such a degree that it can be used as process makeup water.

SECTION V

ENGINEERING APPROACH AND OPERATIONAL PLAN

Description of Treatment Plant Components

The wastewater treatment facility serving Fiber Industries, Inc., Shelby, North Carolina, is located on Company property and is for the exclusive use of the plant. Both domestic and chemical effluent are treated. The design flow of the wastewater treatment plant is 325,000 gallons per day at a BOD_5 loading of 6000 pounds per day. The chemical waste is composed of ehtylene glycol, dimethyl terephthalate, long chain fatty acids such as oleic, linoleic, lauric and their derivatives, quality control laboratory waste, boiler blowdown, Dowtherm, methyl alcohol and cooling water blowdown. The wastewater is routed to the treatment facility as shown in Figures 1 and 2. The units in the system are described as follows:

A. Chromate reduction unit (Grant Unit). The chromate reduction unit is rated at 120 gpm at CrO_4 concentrations up to 300 mg/l. It is designed for continuous operation. The reduction tank is designed for ten minutes retention; the neutralization tank for twenty minutes retention. Both tanks are lined with polyvinyl chloride. The tanks and all the instrumentation for a typical installation are shown in Figure 3. They are housed in a 20' x 30' building, which is located immediately behind the cooling tower.

B. Equalization basins. The chemical waste is routed through three series connected equalization basins. These basins have a total capacity of 190,000 gallons and are equipped with mixers to prevent stratification and short circuiting. In addition to the chemical process waste, cooling tower blowdown is routed to this system after it passes through the chromate reduction system. These basins serve to minimize the effects of spills or intermittant waste loads containing high concentration of organic materials.

C. Plastic Media Trickling Filter (Grant Unit). The plastic media trickling filter is shown schematically in Figure 4. A photograph of the unit is shown in Figure 5. The filter consists of two tiers of media each ten feet thick and twenty-five feet in diameter. Each tier is composed of five two-foot thick layers of polyvinyl chloride media. The geometrical arrangement of the media, each module measuring 2 ft. x 2 ft. x 4 ft., is

critical both for strength and distribution and the arrangement, as shown, is as required. There is a two foot air space between the tiers. The tower is covered on the exterior by galvanized siding except for a two foot air opening around the bottom circumference. The tower is fitted with a four-armed reaction type rotary distributor with variable flow orifice nozzles. The tower rests on a sloped and curbed concrete pad which is connected to a sump which is equipped with a recirculation pump. The pump used to circulate the waste over the tower is variable speed and is rated up to 900 gpm @ 40 ft. TDH. The filter media used in the tower is Koroseal Vinyl Core manufactured by the B. F. Goodrich Company. A schematic and a photograph of this unit is shown in Figures 4 and 5.

D. Aeration basin. Following the plastic media tower is an aeration basin equipped with three mechanical aerators; two rated at 75 HP and one rated at 25 HP. The detention time in the aeration basin is 30 hours based on 325,000 gpd flow and 100% recycle of the clarifier sludge. The Eimco Simcar Aerators were tested in and are rated at 3.5 pounds of oxygen per horsepower hour at standard conditions using water as a test media.

E. Clarifier. The clarifier follows the aeration basin and is of the peripheral flow type. Detention time is 3.6 hours at plant design flow and a 100% sludge recirculation rate. Surface overflow rate is 2125 gallons per day per square foot. Weir overflow rate is 145 gallons per day per linear foot.

F. Polishing ponds. There are two series connected ponds having a total detention time of 25 days at design flow. The sides of these ponds have a 3:1 slope and are operated at a 5 ft. depth. (These two ponds are stocked with catfish, bream and bass).

G. Micro screen or algae screen (Grant Unit). A portion of the effluent from the polishing pond is routed through a rotary drum microscreen to the flocculant and/or carbon treatment unit. This screening unit has a rated maximum flow of 500,000 gpd. It is equipped with a 40 micron (120 x 400 mesh) stainless steel screen. The backwash is routed to the sludge pond. (Figures 6 and 7.)

H. Flocculant and/or carbon unit (Grant Unit). This unit is operated jointly with Item F above and is a packaged unit designed by Permutit. It consists of a dry carbon feeder, a liquid

chemical addition system consisting of two 30 inch diameter x 42 inches high mixing tanks to which is connected double feed pumps. These systems feed into a contact tank which is followed by a clarifier. The contact tank measures 6 ft. in diameter by 9 ft. high and is equipped with a mixer. The clarifier, a Permutit Permu-Jet measures 20 ft. in diameter and 12 ft. deep. A Permutit 10 ft. diameter 12 ft. high valveless filter packed with sand and anthracite serves as a final filter. The system is shown on the schematic in Figure 8. Photographs of the unit appear as Figures 9 and 10.

I. Sludge pond. The earthern sludge pond measures 250' x 500' and operates at a 5' depth. The sides of this pond have a 3:1 slope.

J. Digester. The aerobic digester basin has a capacity of 67,000 cubic feet ans is equipped with a 75 HP and a 25 HP mechanical aerator. The oxygen transfer per horsepower hour is comparable to that for the aerators in the aeration basin as described previously.

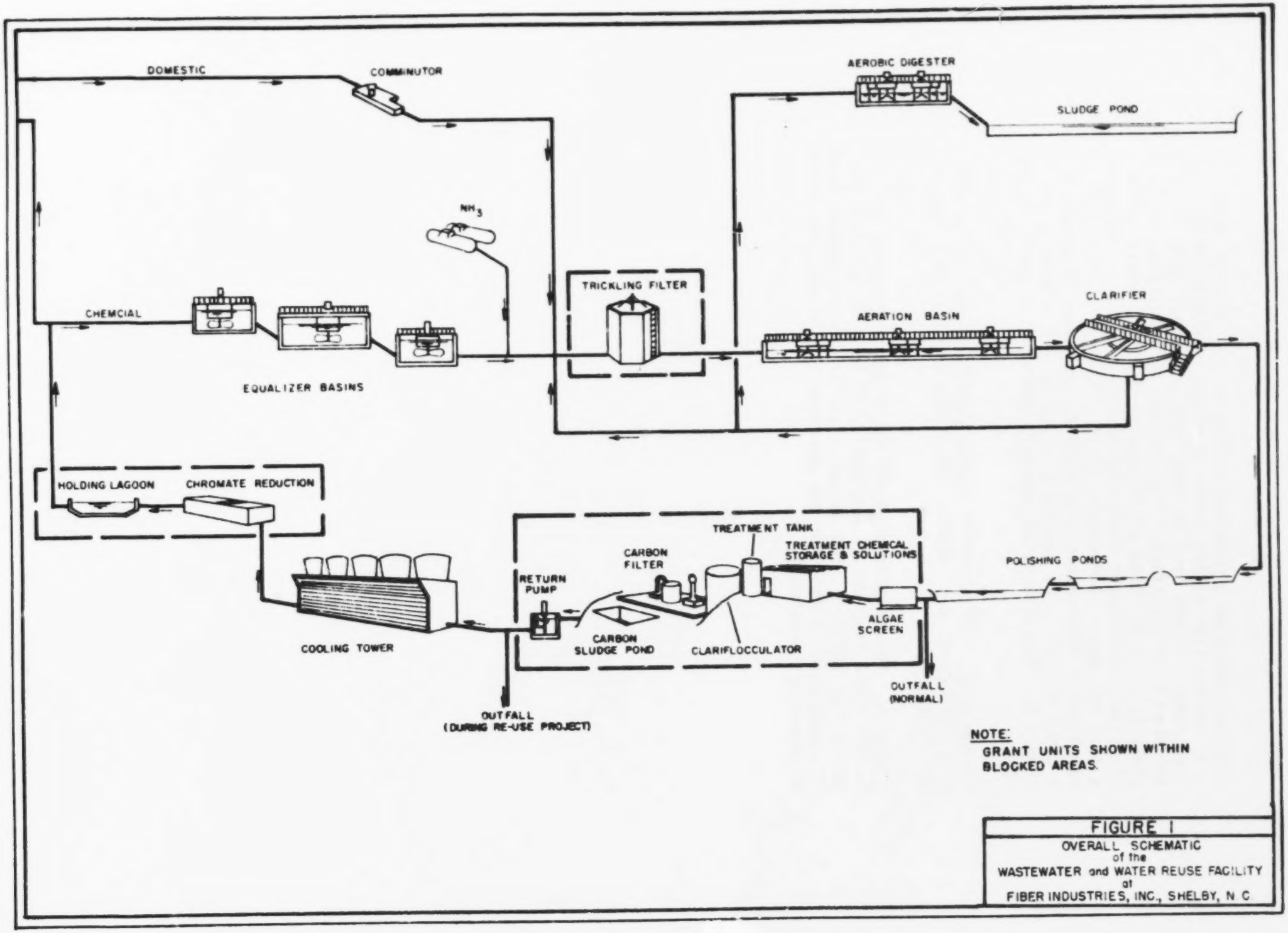


FIGURE 1

OVERALL SCHEMATIC
of the
WASTEWATER and WATER REUSE FACILITY
at
FIBER INDUSTRIES, INC., SHELBY, N C

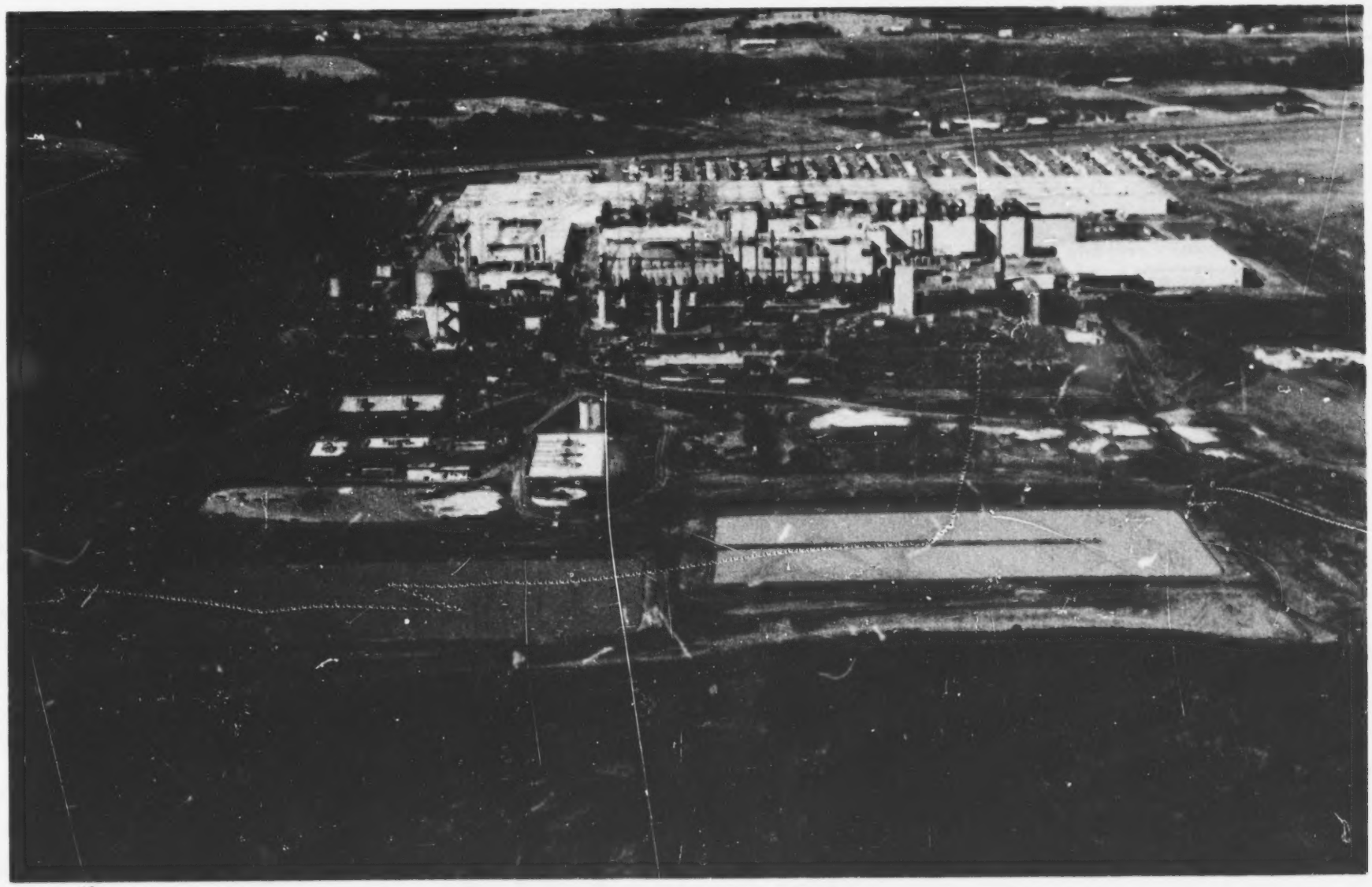


FIGURE 2

Aerial view of Fiber Industries, Inc., Shelby, North Carolina. The Treatment facility shown in the foreground is at the rear of the plant.

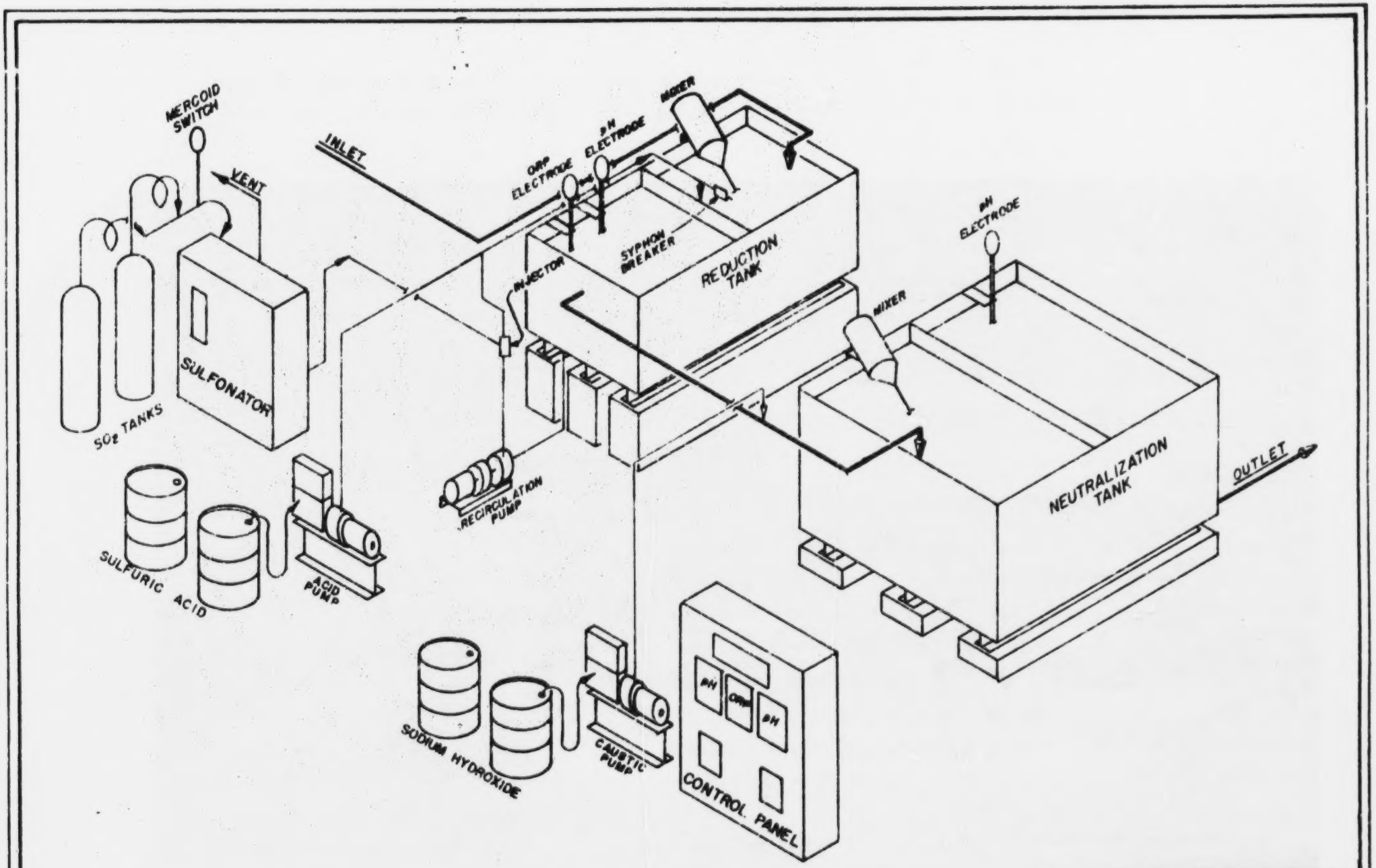


FIGURE 3

SCHEMATIC of CONTINUOUS OPERATION
CHROMATE REDUCTION SYSTEM

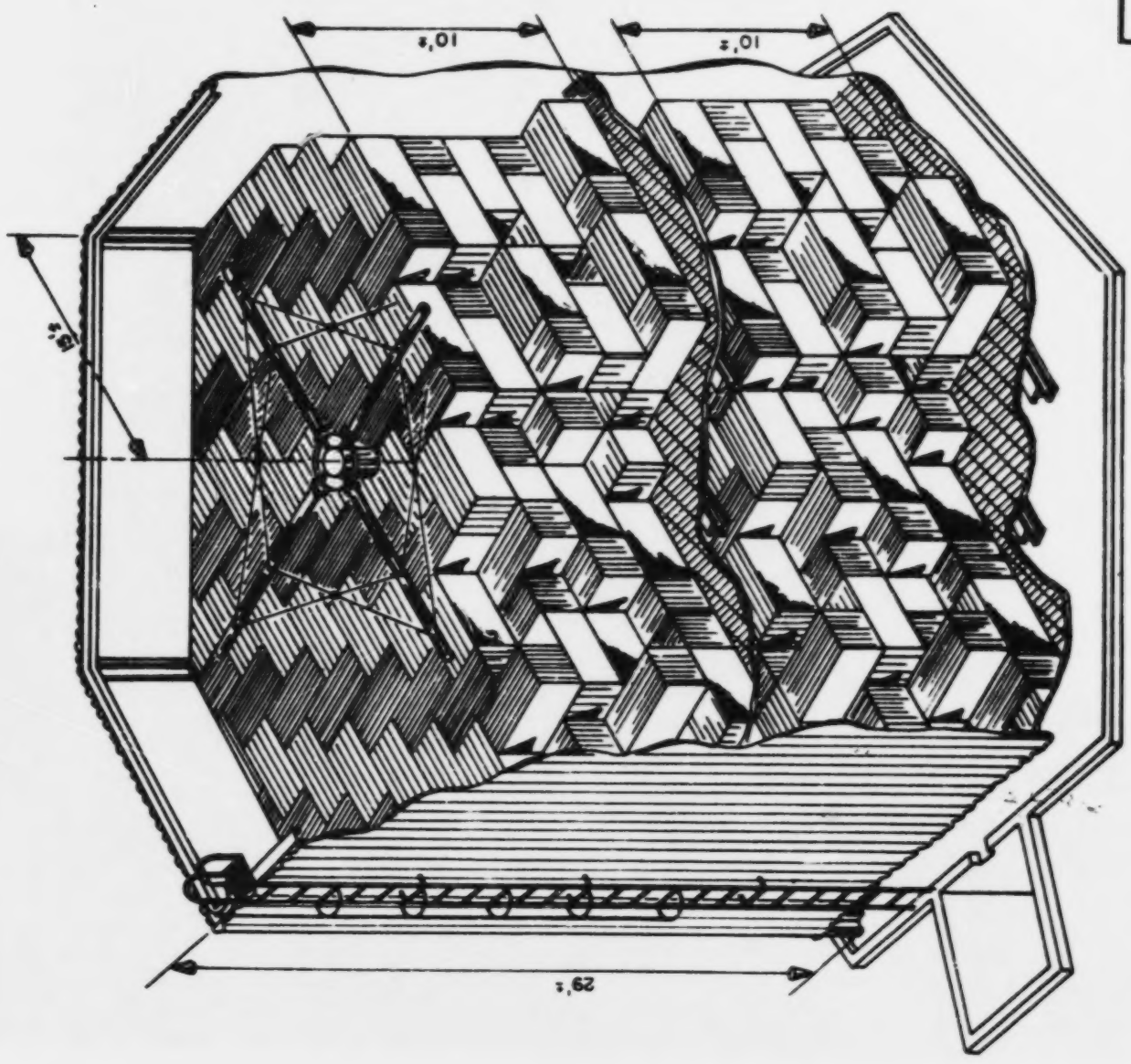


FIGURE 4
SCHEMATIC of PLASTIC MEDIA TRICKLING FILTER showing STRUCTURAL MEMBERS and MEDIA BUNDLE ARRANGEMENT

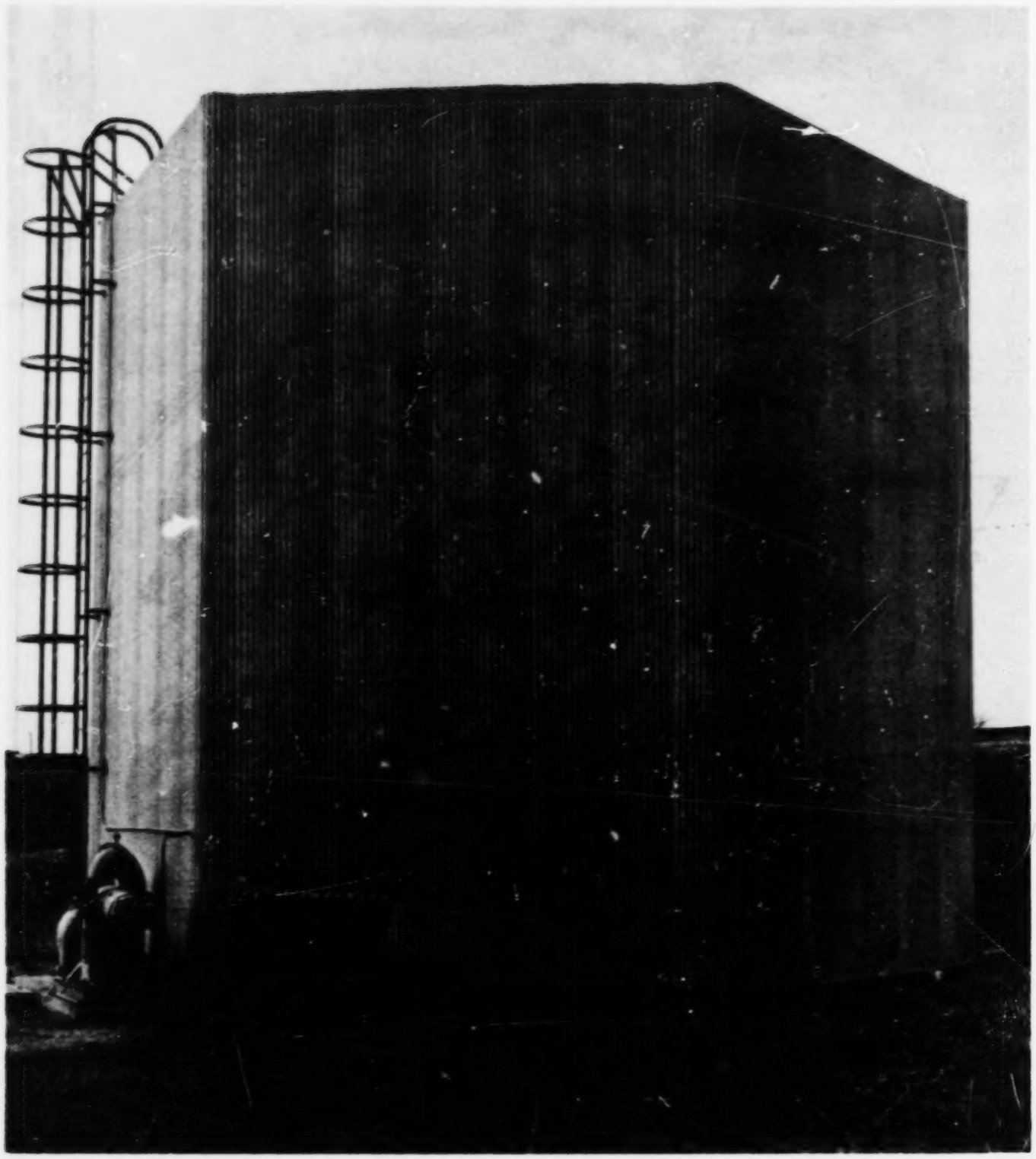
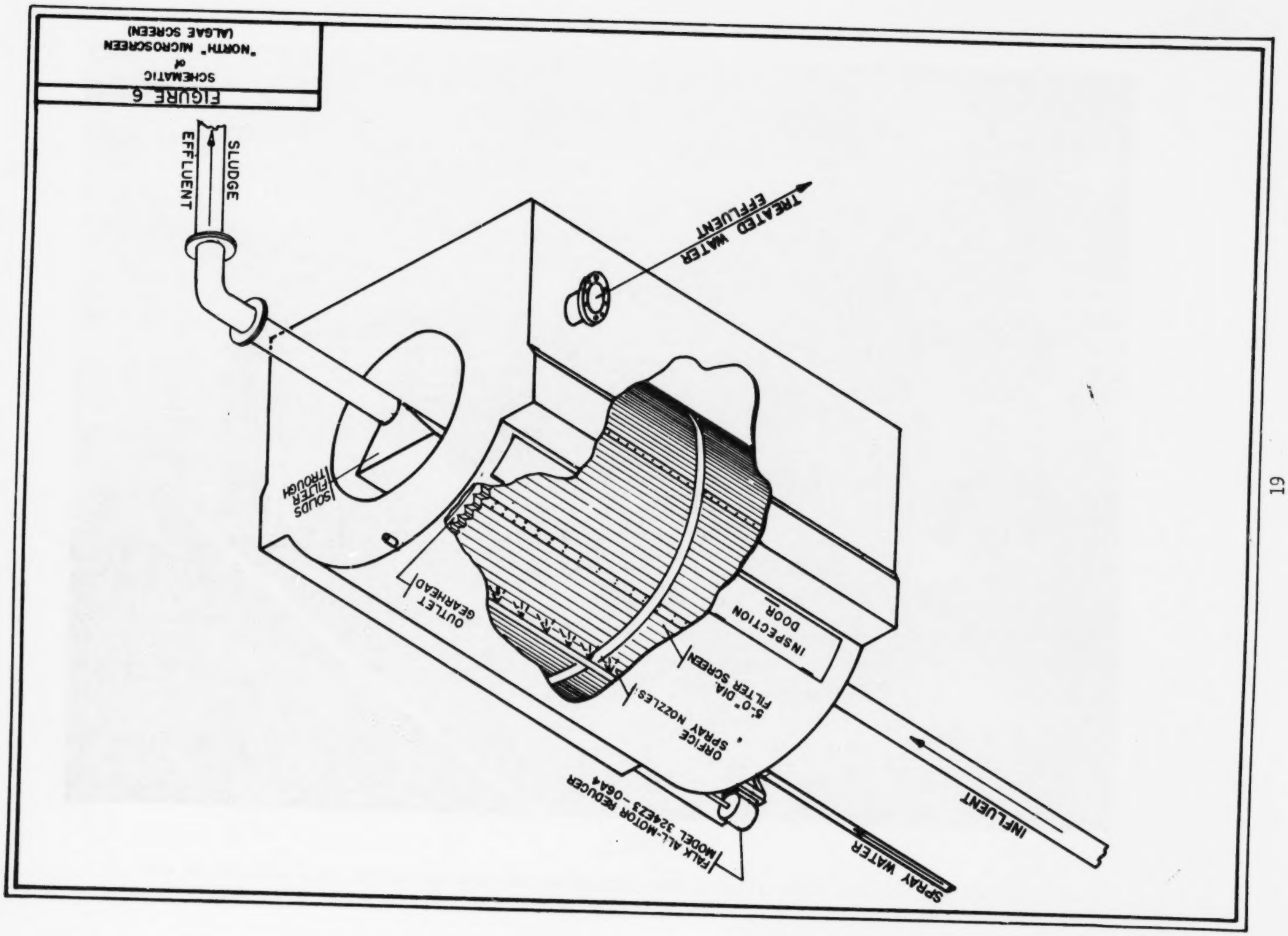


FIGURE 5

Photograph of plastic media trickling filter. Variable speed pump is shown on the left. Samples of plastic media tower packing is shown in the foreground.

FIGURE 6

SCHEMATIC
OF
"NORTH" MICROSCREEN
(ALGAE SCREEN)



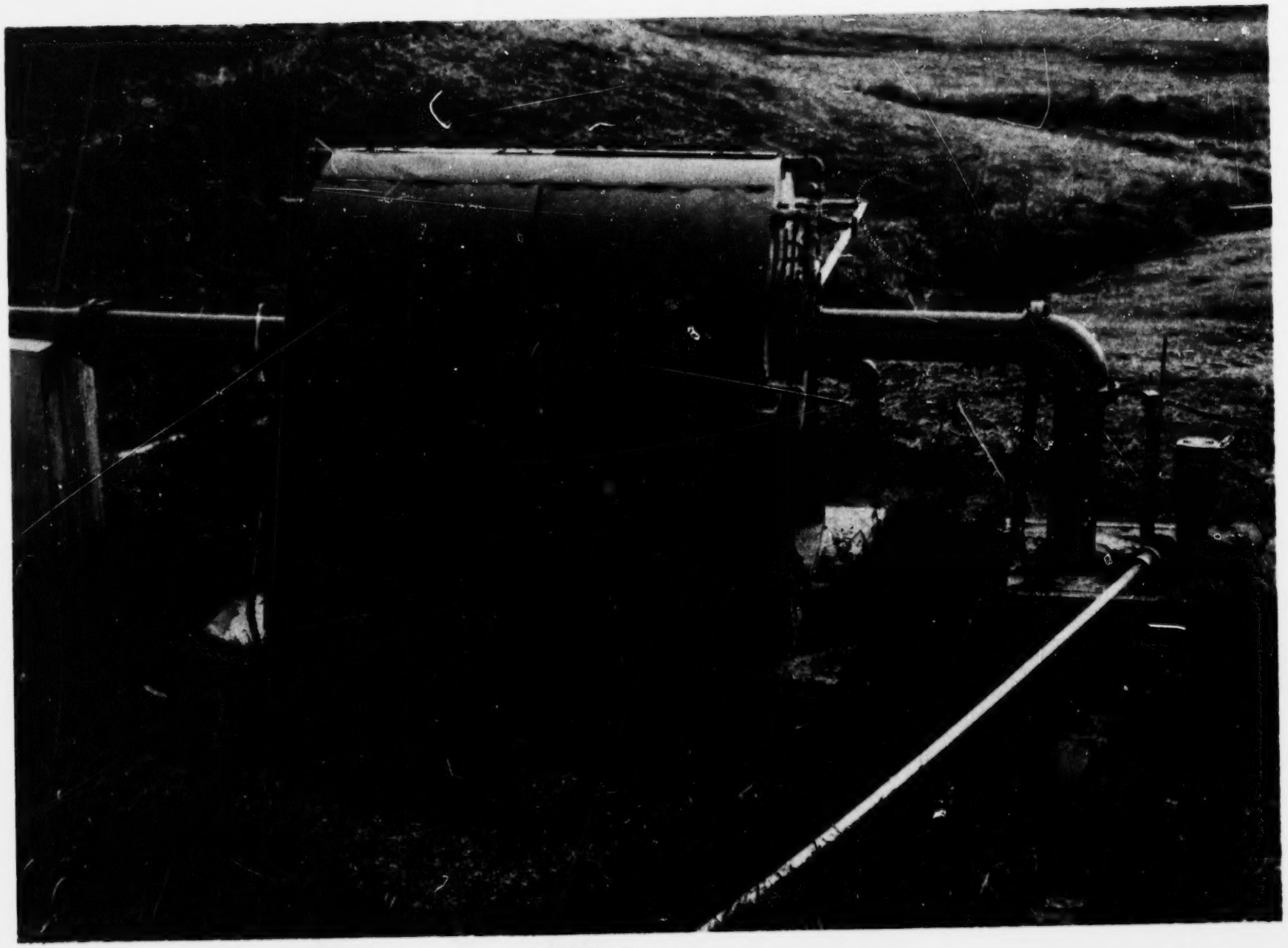


FIGURE 7

Photograph of 500,000 GPD North algae screen installed between polishing pond and carbon and flocculant treatment unit.

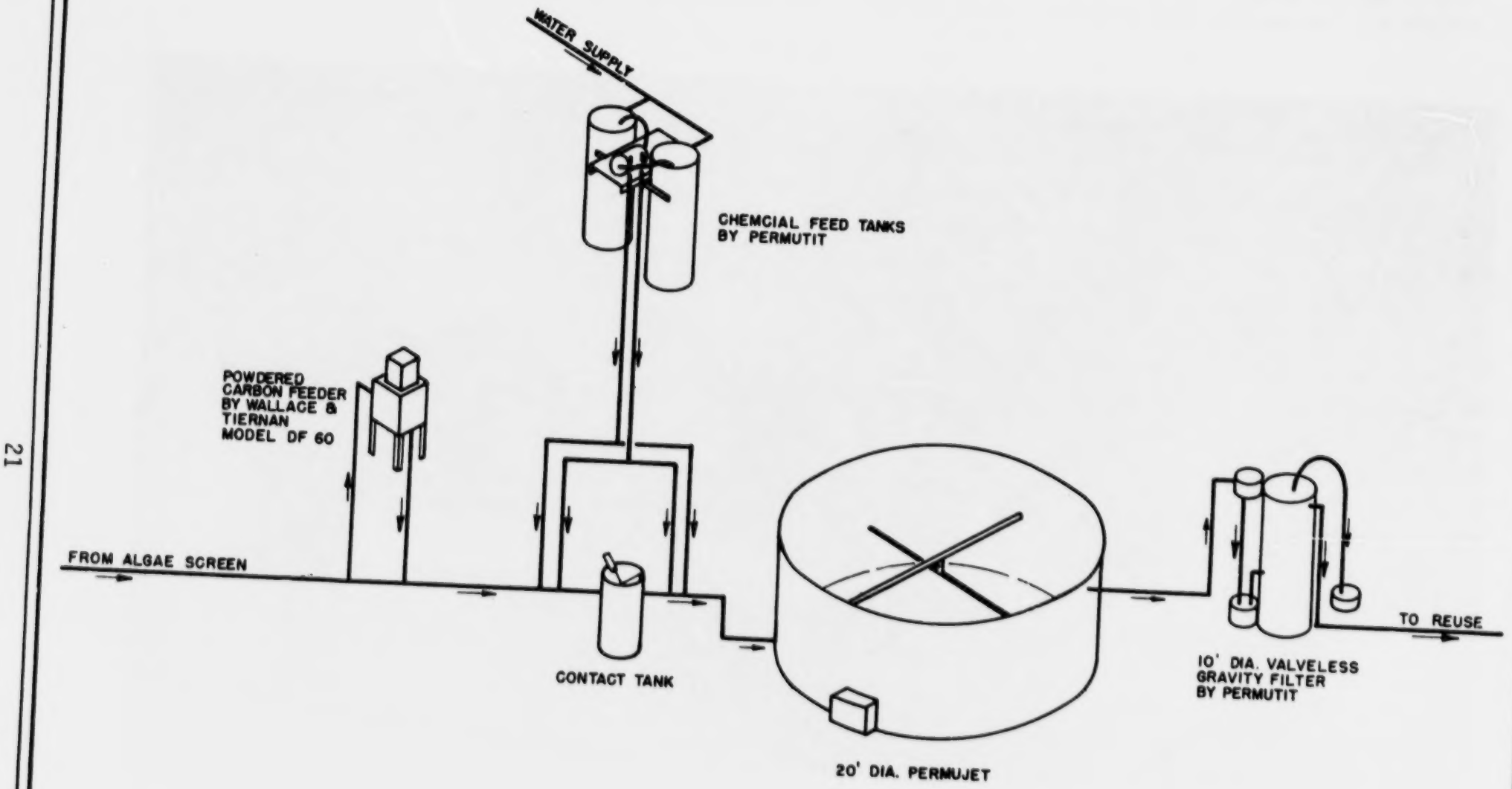


FIGURE 8

SCHEMATIC
of
FLOCCULANT and CARBON UNITS

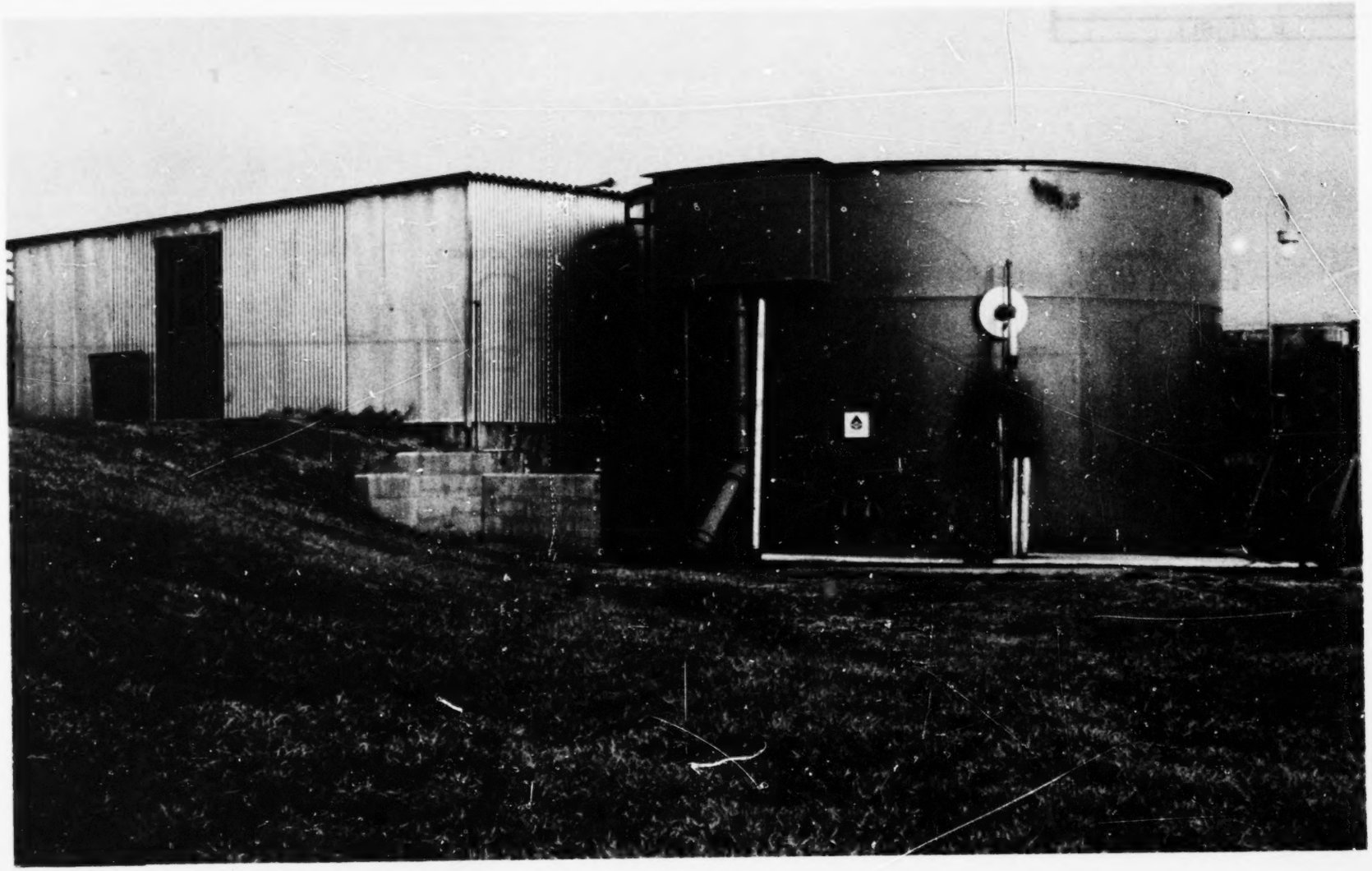


FIGURE 9

Exterior view of Permutit carbon and flocculant treatment unit. The building houses the dry carbon feed unit, the liquid additive mixing tanks and feed pump. The settling tank appears to the right of the photograph.

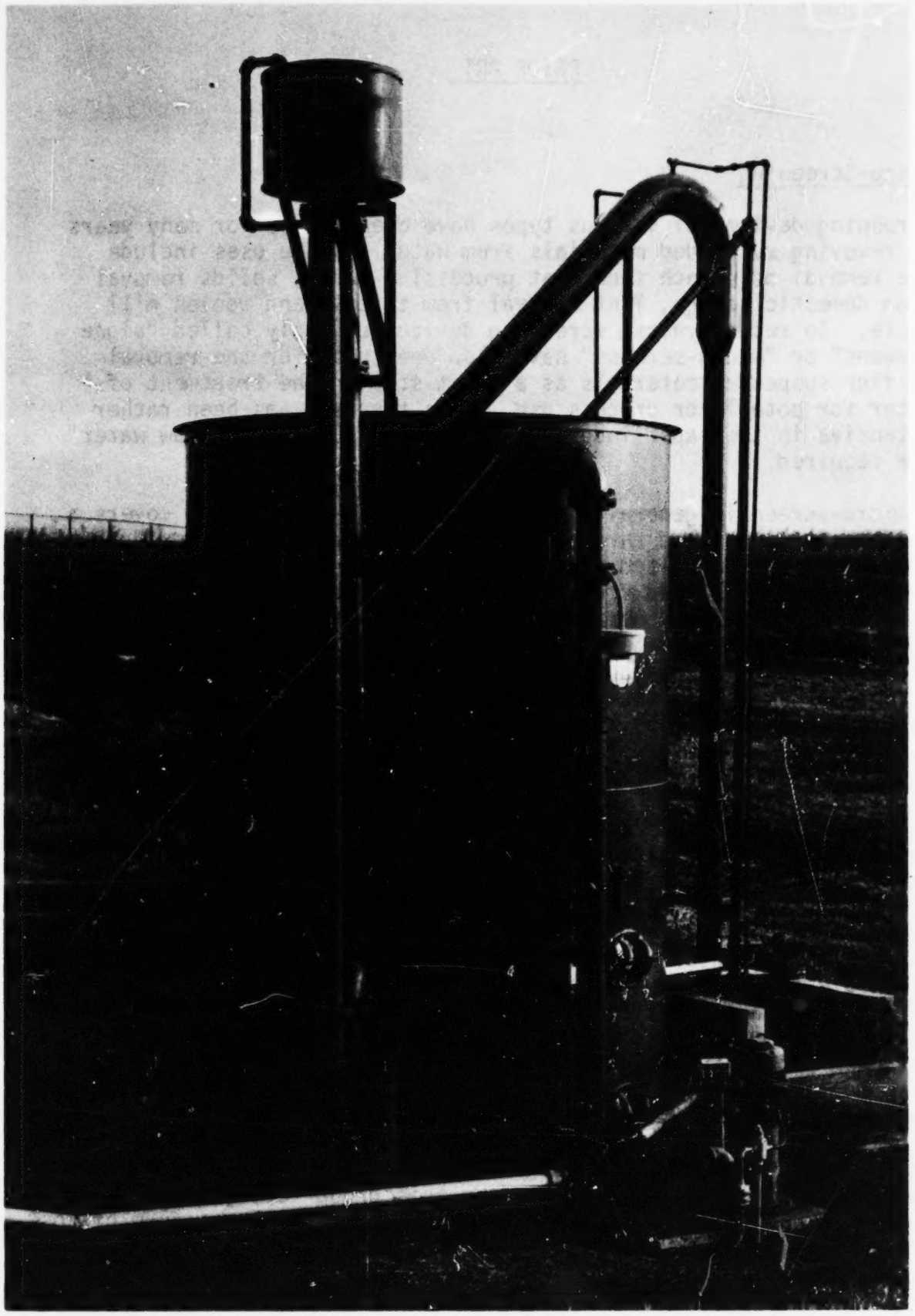


FIGURE 10

The automatic valveless gravity final filter is installed downstream of the settling tank. Filtered water is pumped to the plant cooling tower for use as makeup water.

PRIOR ART

Micro-Screening

Screening devices of various types have been in use for many years in removing suspended materials from water. These uses include the removal of paunch from meat processing waste, solids removal from domestic sewage, lint removal from textile and woolen mill waste. In recent years, screening devices commonly called "algae screens" or "micro-screens" have also been used for the removal of fine suspended materials as a first step in the treatment of water for potable or process use. This type use has been rather extensive in the paper industry where large volumes of "raw water" are required.

A micro-screen is generally a device in which a wire mesh covers a rotating cylinder and through which the liquid to be filtered flow. The residue is deposited on the screen as the liquid passes through. The residue is removed from the screen and deposited in a trough as it rotates past spray nozzles which backwash the screen. Size and amount of suspended material removed depends upon screen size and pattern of weave. Obviously, a finer screen has a better removal capability; however, the finer screens are known to be "blind" and become inoperative (15).

Chemical Treatment

The removal of soluble organic and finely dispersed insoluble organic and inorganic materials by flocculation or by the use of activated carbon has received a great deal of attention in recent years. Crook and Pollis (14) have extensively investigated the use of polyelectrolytes, both cationic and anionic, for use in the removal of such materials from water. They have found that by the use of a polyamine bisulfate salt and similar polymers having molecular weights of 3×10^6, significant quantities of soluble organic and insoluble organic materials from domestic and industrial waste can be removed. This has been proven in field tests by this group. This technique has been applied directly to the treatment of waste water by the Federal Water Quality Administration at Lebanon, Ohio (15) with very promising results. Much of this work was directed towards the use of polymers for pretreatment of wastewater prior to normal secondary treatment. Carbon on the other hand was used by this group for the most part to reduce the BOD_5, COD, color and other parameters as a form of post treatment after secondary treatment. There has been very little work accomplished in the area of post treatment of the waste water using these two methods after the waste has been reduced in BOD_5 by 95

percent or more in a biological treatment system. The water obtained from the 95 percent treatment process is naturally of a much higher quality than that from only secondary treatment and any significant improvement in its quality would be of major interest for those interested in water reuse.

Chromate Reduction

A variety of reducing agents are employed for the reduction of hexavalent chromium (1, 2). Listed below in their order of importance are the most common agents:

1. Sulfur Dioxide (SO_2) (Used in 12090 EUX)
2. Sodium Bisulfite ($NaHSO_3$)
3. Sodium Sulfite (Na_2SO_3)
4. Sodium Metabisulfite ($Na_2S_2O_5$)
5. Ferrous Sulfate ($FeSO_4$)

Of these, sulfur dioxide, ferrous sulfate, and sodium metabisulfite are the most generally used. Typical reactions are illustrated below.

1. $2CrO_3 + 3SO_2 \rightarrow Cr_2(SO_4)_3$ (Used in 12090 EUX)
2. $4CrO_3 + 6NaHSO_3 + 3H_2SO_4 \rightarrow 3Na_2SO_4 + 2Cr_2(SO_4)_3 + 6H_2O$
3. $2CrO_3 + 3Na_2SO_3 + 3H_2SO_4 \rightarrow 3Na_2SO_4 + Cr_2(SO_4) + 3H_2O$
4. $4CrO_3 + 3Na_2S_2O_5 + 3H_2SO_4 \rightarrow 3Na_2SO_4 + 2Cr_2(SO_4)_3 + 3H_2$
5. $2CrO_3 + 6FeSO_4 .7H_2O + 6H_2SO_4 \rightarrow 3Fe_2(SO_4)_3 + Cr_2(SO_4)_3 + 48H_2O$

All of the above reactions occur in acidic media, some necessitating the addition of an acid such as sulfuric to insure a rapid reaction rate and minimum quantities of reducing agent. All of the procedures convert hexavalent chromate to trivalent chromium and must therefore be followed by a supplementary step to remove trivalent chromium from solution. This is accomplished by elevating the pH of the waste stream to 8.0 - 9.0 and precipitating the chromium as chromic hydroxide. Lime is most often utilized for this purpose. Sodium hydroxide or any other available alkali may be preferred in smaller installations because of the greater ease of handling and its immediate availability. The precipitation reaction is as follows:

$$Cr_2(SO_4)\,Cr_2(SO_4)_3 + 3Ca(OH)_2 \rightarrow 2Cr(OH)_3 + 3CaSO_4$$

Adequate time must be provided for the settling of the chromic hydroxide precipitate to assure its removal.

Ferrous sulfate is one of the early chemicals used and is still applicable today for smaller systems or where improved settling rates are especially desirable. The ferrous ion formed in the reduction reaction precipitates in the alkaline solution forming ferric hydroxide which serves as a coagulant to assist in bringing down the slow settling chromic hydroxide. Generally, ferrous sulfate would be supplemented by one of the other reducing agents in larger systems due to economic considerations.

Plastic Media Trickling Filter

Trickling filters in themselves are not new, in fact, they have been used quite extensively for the treatment of wastewater for many years. Early designs consisted of merely discharging waste over a pile of rocks. Micro-organisms in the form of a slime layer developed on the rock pile and the waste in some manner and to some degree was treated.

Many refinements have been made as experience has been gained and the standard trickling filter of today consists of a distribution system which sprays waste over a uniform bed of rock or slag or some other inorganic media. The bed is fitted with a ventilation system, tile underdrain and possibly recirculation pumps. These traditional systems are limited in both hydraulic and organic loading due to the limited surface area of the media and free space between units of the media.

Recently, progress has been made in the use of synthetic materials as media in trickling filters. Process systems have been developed wherein a polyvinyl chloride honeycomb has been formed and used as the media. Such a system is referred to as a plastic media trickling filter, and it has distinct advantages over the conventional filter. Some of the major advantages are as follows:

1. The plastic media provides more surface area per cubic foot than traditional inorganic media.

2. The plastic media possesses approximately 97 percent void space as compared with 45 percent for slag and rock.

3. Plastic media requires less land area because of its vertical construction.

4. Plastic media requires less structural support.

5. No elaborate or expensive tile underdrain system is necessary.

6. A preformed media of uniform and controlled quality is assured as compared to the randomness of rock or slag.

Various literature references in the past few years have contained loading data for plastic media filters and the subsequent BOD reduction. Some typical data on this work is as follows:

TABLE 1

TYPICAL HYDRAULIC AND ORGANIC LOADINGS

FOR PLASTIC MEDIA TRICKLING FILTERS (11, 12, 13)

Type of Waste	Organic Loading #/day/1000 c.f.	Percent BOD Reduction
Domestic	92	72
Domestic	370	57
Textile	65	60
	106	58
Pulp & Paper	600	43
Frozen Foods Processing	600	53
Fruit & Vegetable Processing	102	80
Brewery Wastes	126	80

Unusual and sometimes unexpected results have been obtained by the use of these filters. In an attempt to explain some of the phenomena many persons have presented their observations. Chipperfield's (12, 13) work and his extensive review of other work suggests that since "there is a constant percentage removal of BOD_5 from solution with increasing load that the biological filtration process at high loadings is similar to the absorption process, and thus, in a given unit, the only limitation to the amount of BOD removed per unit volume of filter would be the availability of the treatment bios to the substrate". With Chipperfield's work as background it would appear that under a given set of loading conditions a situation would develop wherein the bios become the limiting factor. If more bios could be introduced then the amount of BOD removal could be increased. Such a situation could be produced if mobile biota, activated sludge for example, could be introduced into the system to supplement the stationary bios present on the trickling filter structure. This can be accomplished by placing the filter ahead of an activated sludge

system and recycling sludge directly to the trickling filter. The effluent from the tower would then discharge into the aeration basin and then to the clarifier. Such an arrangement was a part of this project and will be discussed in the experimental section.

Chipperfield also states that at loadings of 260-370 pounds per 1000 cubic feet per day, removals lie between 40 and 65% depending on the waste. It was also stated by Chipperfield that recycle in sufficient amount to maintain the minimum wetting rate for the filter was optimum since excess recirculation above this rate may cause some decrease in percentage BOD removal.

SECTION VI

OPERATIONAL AND EXPERIMENTAL ASPECTS OF THE PROJECT

OPERATION

Chromate Reduction Unit

The chromate reduction system was designed to receive effluent from the cooling tower at rates of up to 120 gpm. The influent to the unit contains up to 30 mg/l chromium (VI) as chromate and the effluent from the unit contains chromium (III). Internally the system has two tanks in which reactions occur. The first tank is the reduction tank and it is equipped with an oxidation reduction potential electrode (ORP electrode) and a pH electrode. The electrical signal generated by the ORP electrode is directed to a potentiometer type recorder equipped with pneumatic control. The output from this controller is fed to a pneumatically positioned flow regulator valve within a sulfonator which in turn automatically proportions the feed rate of SO_2 to the system in accordance with the demands of the ORP electrode. This feed rate is, therefore, a function of the unreduced chromium (VI) in the system since the ORP cell measures the potential difference in the chromium (VI) and chromium (III) in the system. The pH system operates similarly but in this case controls an acid feed pump. The second tank or neutralization tank is series connected to the first and is equipped with a pH system which operates an alkali pump in a similar manner.

Based on the day to day demands for cooling tower operation and blowdown, the operating personnel preset the rate of flow and the ORP and pH set points. In addition, they replace the chemical drums and gas cylinders as necessary.

During the grant period a number of minor operational difficulties were encountered. They are as follows:

1. Flow fluctuations. The chromate reduction system is fed from the cooling tower riser. This riser is subject to the pressure fluctuations and this in turn results in flow fluctuations to the chromate reduction unit. This was a minor problem and was resolved by the installation of a feed pump.

2. Electrode poisoning. After about eight weeks of operation, it was found that the ORP system was slowly becoming insensative. The cause was investigated and it was concluded that Dowtherm, which had been inadvertantly spilled into the cooling system, was coating the dip type electrodes. This problem continues to occur and ORP electrodes must be changed every three to four months as a result.

Plastic Media Trickling Filter

The plastic media trickling filter was designed and constructed in such a manner as to allow a 10 ft. deep tier of media to be readily removed or a 10 ft. tier of media to be readily added. The 10,000 cubic foot unit as constructed had a 25 ft. diameter and was hexagonal in shape. It was fitted with a standard rotary distributor. The recirculation pump was installed in the sump and a capacity ranging up to 900 gpm. Valving and piping arrangements to the tower were designed so that sanitary and chemical waste could be fed to the tower and treatment of these wastes could be observed as a slime layer built up on the tower. An alternate method of operation was provided where in return sludge could be blended with this waste and the blend pumped across the tower for observation. Operational problems associated with this unit are as follows:

1. Freezing. At ambient temperatures below 10°F the wastewater freezes when it is sprayed out of the rotary distributor. During the early part of 1970 the unit was shut down no less than sixty days due to freezing. Once the interior of the tower within the media is frozen, it takes approximately ten days of above freezing temperatures (during daylight hours) to thaw. Placing the tower within a heated building or warehouse would alleviate this problem, but it may be economically unattractive. It should be noted that the surface of the aerator basin containing the mechanical aerators freezes under the same ambient conditions with the resulting overloading and shutting down of the aerators. However, the aeration basin thaws in about one-tenth of the time required for the plastic media tower. No structural damage to the media or to the twoer structure occurred during the freeze. The mechanical effect of the freeze thaw cycle on the media should be closely observed in the future, however, in order to gain knowledge in this area.

2. Rotary Distributor Orifice Plugging. When the rotary distributor was first placed in operation, the comminutor in the sanitary sewer at the head of the plant was out of order. It was thought that the solids materials might tend to plug the orifices of the distributor. Such was not the case. No plugging was noted.

Microscreening and Chemical Treatment Unit Operation

Influent to this system comes from the polishing ponds. The water first passes through the microscreen into a piping system fitted with an in-line mixer and then into a contact tank. From the contact tank the water continues on through a clarifier to a final filter and then is pumped back to the cooling tower for use. Backwash from the microscreen, waste sludge from the clarifier and backwash from the final filter are pumped to the treatment plant sludge pond. The operator regulates the rate of flow by utilizing a valve and rotometer. Chemicals either powdered or liquid are introduced into the water prior to the contact tank. Sludge wasting from the clarifier is accomplished on a daily basis as necessary by the operator. Backwashing of the final filter is automatic and is controlled by pressure drop across the final filter.

Equipment problems encountered during the study are as follows:

1. The backwash spray nozzles on the microscreen became frozen during below freezing ambient conditions. This problem can be resolved by placing the filter in a protected area.

2. The rotor assembly in the clarifier is impulse driven by pumped recirculated water. As the sludge blanket built up in the clarifier, there was a tendency for the rotor to stall. This in turn caused a major sludge build-up and the entire clarifier system became inoperative. A permanent resolution for this problem is the installation of a direct motor drive on the rotor assembly of the clarifier since the impulse drive does not appear to be sufficient.

3. During summer operation slime growth developed on the screens of the microscreen and impaired flow thereby necessitating cleaning. This became rather common and time consuming and was at its peak during algae bloom periods in the polishing ponds. This was deliberately allowed to happen in order to observe its effect on the operation of the filter. The microscreen is fitted with a steam tap so that the backwash nozzles can be utilized for steam cleaning of the screen under such conditions; therefore, a permanent fix is contained on the unit itself.

EXPERIMENTAL

The basic concept in this demonstration project was to install the grant units in the existing treatment plant in such a manner that all of the wastes, including cooling tower blowdown, would be routed to the treatment plant, treated to a high degree and discharged with up to 25 percent being reused for cooling tower makeup. The grant units were to be operated and evaluated as appropriate over their operational ranges. Sampling points were to be established at such locations and taken at such frequencies as to evaluate the operation of the plant. The sampling points are shown in Figure 11. These points are located before and after each unit operation and/or before and after each point of combination or recirculation of waste, sludge or effluent.

Chromate Reduction

The chromate reduction unit was placed in operation and evaluated initially for hydraulic capacity and then for efficiency of chromate reduction. The evaluation consisted of operating the system at selected blowdown rates and observing the adequacy of the operation of the various components. It was established that the unit would operate properly over the design range of flows and chromate concentrations. Thereafter the unit was operated on a day to day basis at various blowdown rates as dictated by cooling water solids concentrations adjustment requirements. This ranged from no blowdown during some winter periods to 100 gpm blowdown on some summer days. All effluent from the chromate reduction unit was directed to a settling pond which also served as a surge pond. Effluent from this pond was directed to the treatment plant at a constant rate by valving so that shock loading of the treatment plant would not occur. The effluent ultimately entered the treatment plant through the chemical sewer system wherein it was diluted. Data collected during these evaluation periods is presented in Table 2.

TABLE 2

CHROMATE REDUCTION UNIT OPERATIONAL DATA

		Influent to Chromate Unit		Influent to Waste Treatment Plant		Effluent From Treatment Plant
Blowdown Rate, gpm	Duration of Test (Days)	Cr^{+6} Range mg/l	Biocide Range mg/l & Type	Cr^{+6} Range mg/l	Biocide Range mg/l	Biocide Range mg/l
48	34	10-20	36 (Note 1)	0	5-7	0
80	39	10-20	8-19 (Note 2)	0	0-9	0
			0-37 (Note 3)	0	(Note 7)	0
5-94	30	10-20	30 (Note 4)	0	(Note 6)	0
25-60	41	8-26	8-17 (Note 2)	0	0-6	0
			0-37 (Note 3)	0	(Note 7)	0
21-91	30	9-20	0-57 (Note 5)	0	(Note 6)	0

(1) Betz C-30 bis (trichloromethyl) sulfone and methylene bisthiocyanate blend.
(2) Betz A-9 sodium pentachlorophenate.
(3) Betz C-5 1,3 dichloro-5, 5-dimethylhydantoin.
(4) Betz J-12 N-alkyl dimethyl benzyl ammonium chloride.
(5) Betz C-34 sodium dimethyl dithiocarbamate and disodium ethylene bisdithiocarbamate.
(6) Destroyed in reduction tanks.
(7) Dissipates in cooling tower in six hours and is not contained in blowdown.

Plastic Media Trickling Filter

The plastic media trickling filter was evaluated in a manner similar to that described by Egan (14), Chipperfield (12, 13), and contained in the Sewage Treatment Plant Design Manual (11). These methods are considered standard for the art and are summarized as follows as they apply to this project:

1. Mode A. In this mode the combined sanitary and chemical waste including cooling tower blowdown were routed across the tower. The efficiency of the plastic media was established by the evaluation of data from samples taken before and after the tower. BOD_5 was determined on the settled effluent and not on a completely mixed sample.

2. Mode B. Mode B is identical to Mode A except that the return sludge from the clarifier is combined with the sanitary waste, chemical waste and cooling tower blowdown and this composite is pumped across the tower. The BOD_5 reduction (as well as other parameters) under this mode of operation is derived by calculations using the volume and BOD_5 concentration in the combined sanitary waste, chemical waste and cooling tower blowdown with similar data on effluent from the unit which includes the before mentioned streams plus the sludge recycle.

3. Mode C. Mode C is a special mode of operation and evaluation wherein only a portion of the plastic media tower is used with the same waste volume. Higher hydraulic and organic loadings per unit area and per unit volume respectively can be obtained. BOD_5 reduction (as well as other parameters) was determined as in Mode B above.

The BOD_5 reduction data obtained during each of the modes described is presented in Figures 13, 14, 15 and 16. In operating at these modes and in presenting the data the following terms are used as they apply to this project.

1. Hydraulic loading. Hydraulic loading is expressed in gallons per square foot per minute. It is based on the actual calibrated pumping rate.

2. Organic loading. This is expressed in pounds per cubic foot of media per day. It is based on the BOD_5 of the treatment plant influent and does not include BOD_5 contained in recycle, if any, from the clarifier.

3. Recycle rate. Recycle is expressed as the ratio of the trickling filter pump output to total treatment plant influent. Instances where sludge return from the clarifier is being combined with the treatment plant influent and treated across the tower, the recycle ratio is the ratio of the trickling filter pump output to the combined treatment plant influent and sludge return.

Chemical Treatment and Microscreening

The experimental portion of the chemical treatment including the microscreening unit was broken into two phases. The first phase utilized polishing pond water as feed and the second phase utilized clarifier water as feed. In both instances jar tests were conducted utilizing alum, various polymers and polymer combinations and powdered carbon. Materials that showed promise in jar tests were evaluated on a full scale trial. Each chemical additive that was evaluated on a full scale trial is presented in Table 3 and Table 4. The manufacturers data sheet for each additive used appears in the appendix.

Sampling

Initially sampling was conducted daily by use of automatic continuous non-proportional dipper samplers at the points shown on sampling plan (Figure 11). The use of the automatic samplers was discontinued and daily grab samples were taken after it was established that the two methods gave comparable results. Sampling points were selected so that each unit operation could be bracketed and its performance evaluated on a daily basis throughout the grant period. The data presented in the tables and figures which follow was compiled using grab samples. The data obtained was grouped into classes, the mean and standard deviation for each class was determined; the mean was then evaluated and plotted. Each point on the graph in the figures which follow represents a class consisting of not less than ten analyses.

TABLE 3

DATA FROM MICROSCREENING AND CHEMICAL TREATMENT UNIT

UTILIZING POLISHING POND EFFLUENT - TREATMENT ACROSS MICROSCREEN AND CHEMICAL TREATMENT UNIT

Treatment Type and Dosage (1,2)	COD Initial mg/l	COD Final mg/l (% Reduced)	Total Phosphate Initial mg/l	Total Phosphate Final mg/l (% Reduced)	Total Nitrogen Initial mg/l	Total Nitrogen Final mg/l (% Reduced)	Turbidity Initial Units	Turbidity Final Units (% Reduced)	Color Initial Units	Color Final Units (% Reduced)	Fixed Solids Initial mg/l	Fixed Solids Final mg/l (% Reduced)	Notes
1. Alum 85.5 mg/l Aqua Nuchar A 60 mg/l	161	90 (44)	3.6	0.9 (75)	0.23	0.14 (39)	-	- (-)	200	60 (70)	241	292 (0)	19 Days May 1969
2. Alum 102 mg/l Aqua Nuchar A 120 mg/l C-25 8 mg/l	174	89 (49)	4.3	1.0 (77)	0.12	0.08 (33)	59	22 (63)	245	80 (67)	237	305 (0)	24 Days May - June 1969
3. Alum 43.5 mg/l Aqua Nuchar A 84 mg/l Poly Floc 1160 1 mg/l	197	172 (13)	2.9	1.9 (34)	0.0	0.0 (0)	88	84 (5)	260	248 (5)	403	413 (0)	12 Days July 1969
4. Alum 200 mg/l Aqua Nuchar A 182 mg/l Poly Floc 1160 1 mg/l	100	78 (22)	1.7	0.7 (58)	0.0	0.0 (0)	36	17 (53)	124	60 (52)	326	372 (0)	8 Days, August 1969
5. Alum 163 mg/l Aqua Nuchar A 128 mg/l Poly Floc 1160 1 mg/l	140	117 (16)	3.9	1.7 (56)	1.3	0.0 (100)	163	38 (77)	163	112 (31)	338	369 (0)	12 Days, July - August 1969
6. C-225 6.3 mg/l C-25 15 mg/l	124	90 (27)	2.5	2.4 (2)	0.0	0.0 (0)	51	17 (67)	114	50 (56)	354	386 (0)	13 Days, October 1969
7. Aqua Rid 49-701 13 mg/l Aqua Rid 96-549 30 mg/l	100	90 (10)	7.3	7.3 (0)	0.09	0.06 (33)	50	21 (58)	90	49 (46)	-	- (-)	8 Days, October 1969
8. Alum 44 mg/l Poly Floc 1160 4 mg/l	140	80 (43)	3.3	3.2 (3)	0.13	0.08 (39)	53	14 (74)	179	42 (77)	346	419 (0)	11 Days, Nov. 1969
9. C-225 13 mg/l C-25 15 mg/l Aqua Nuchar 180 mg/l	126	87 (31)	4.6	0.8 (82)	0.0	0.0 (0)	90	30 (30)	300	98 (67)	352	359 (0)	7 Days, Sept. 1969

Notes: (1) See appendix II for trade name product identification.

(2) Preliminary jar tests gave indication of dosage which was verified and refined by actual plant operation. The actual dosage used under refined conditions of operation is presented in this table.

TABLE 4

DATA FROM MICROSCREENING AND CHEMICAL TREATMENT UNIT

CLARIFIER EFFLUENT - TREATMENT ACROSS CHEMICAL UNIT

Treatment Type and Dosage (1,2)	COD Initial mg/l	COD Final mg/l (% Reduced)	Total Phosphate Initial mg/l	Total Phosphate Final mg/l (% Reduced)	Total Nitrogen Initial mg/l	Total Nitrogen Final mg/l (% Reduced)	Turbidity Initial Units	Turbidity Final Units (% Reduced)	COLOR Initial Units	COLOR Final Units (% Reduced)	Fixed Solids Initial mg/l	Fixed Solids Final mg/l (% Reduced)	NOTES
1. Control, No Chemical Treatment, screened & filtered	320	470 (0)	5.7	2.0 (71)	1.3	0.18 (86)	160	70 (56)	422	183 (57)	442	392 (11)	7 Days, Feb. 1970
2. Alum 75 mg/l	350	255 (27)	9.0	1.0 (88)	0.20	0.20 (0)	120	45 (63)	193	139 (28)	489	440 (10)	12 Days, Feb. & March 1970
3. Alum 75 mg/l C-225 3 mg/l	250	223 (11)	5.4	5.1 (6)	5.5	7.1 (0)	54	38 (30)	135	105 (22)	492	502 (0)	16 Days, March 1970
4. Alum 45 mg/l C-225 2 mg/l Aqua Nuchar A 250 mg/l	160	90 (44)	10.9	9.2 (16)	0.52	0.18 (65)	38	37 (4)	97	85 (12)	540	516 (4)	8 Days, March 1970
5. Alum 36 mg/l C-225 2 mg/l Darco S-51 200 mg/l	139	75 (46)	6.2	5.9 (5)	2.3	4.4 (0)	48	50 (0)	120	128 (7)	264	272 (0)	15 Days, April 1970
6. Alum 100 mg/l Darco S-51 200 mg/l	-	- (-)	7.5	3.3 (56)	2.7	1.6 (40)	-	20 (-)	60	60 (0)	-	- (-)	8 Days, April 1970

Notes: (1) See appendix I1 for trade name product identification.

(2) Preliminary jar tests gave indication of dosage which was verified and refined by actual plant operation. The actual dosage used under refined conditions of operation is presented in this table.

TABLE 5

EFFECTIVENESS OF POLISHING PONDS AS A TERTIARY TREATMENT UNIT

(TWO PONDS, SERIES CONNECTED, THIRTY DAYS DETENTION, FIVE FOOT OPERATION DEPTH)

	BOD		COD		Total Nitrogen		Total Phosphate		Fixed Solids	
	Initial mg/l	Final mg/l (% Reduced)	Initial mg/l	Final mg/l (% Reduced)	Initial mg/l	Final mg/l (% Reduced)	Initial mg/l	Final mg/l (% Reduced)	Initial mg/l	Final mg/l (% Reduced)
March-April-May 1969	25	13 (48)	189	164 (13)	0.24	0.19 (21)	2.7	1.3 (52)	249	230 (8)
June-July-August 1969	12	12 (0)	149	161 (0)	1.70	0.23 (86)	5.0	3.1 (38)	436	317 (27)
September-October-November 1969	16	9 (44)	160	129 (19)	1.69	0.10 (94)	5.3	2.6 (50)	464	383 (17)
December - 1969 January - February 1970	75	77 (0)	516	389 (25)	1.02	0.22 (78)	6.1	3.6 (41)	420	349 (17)

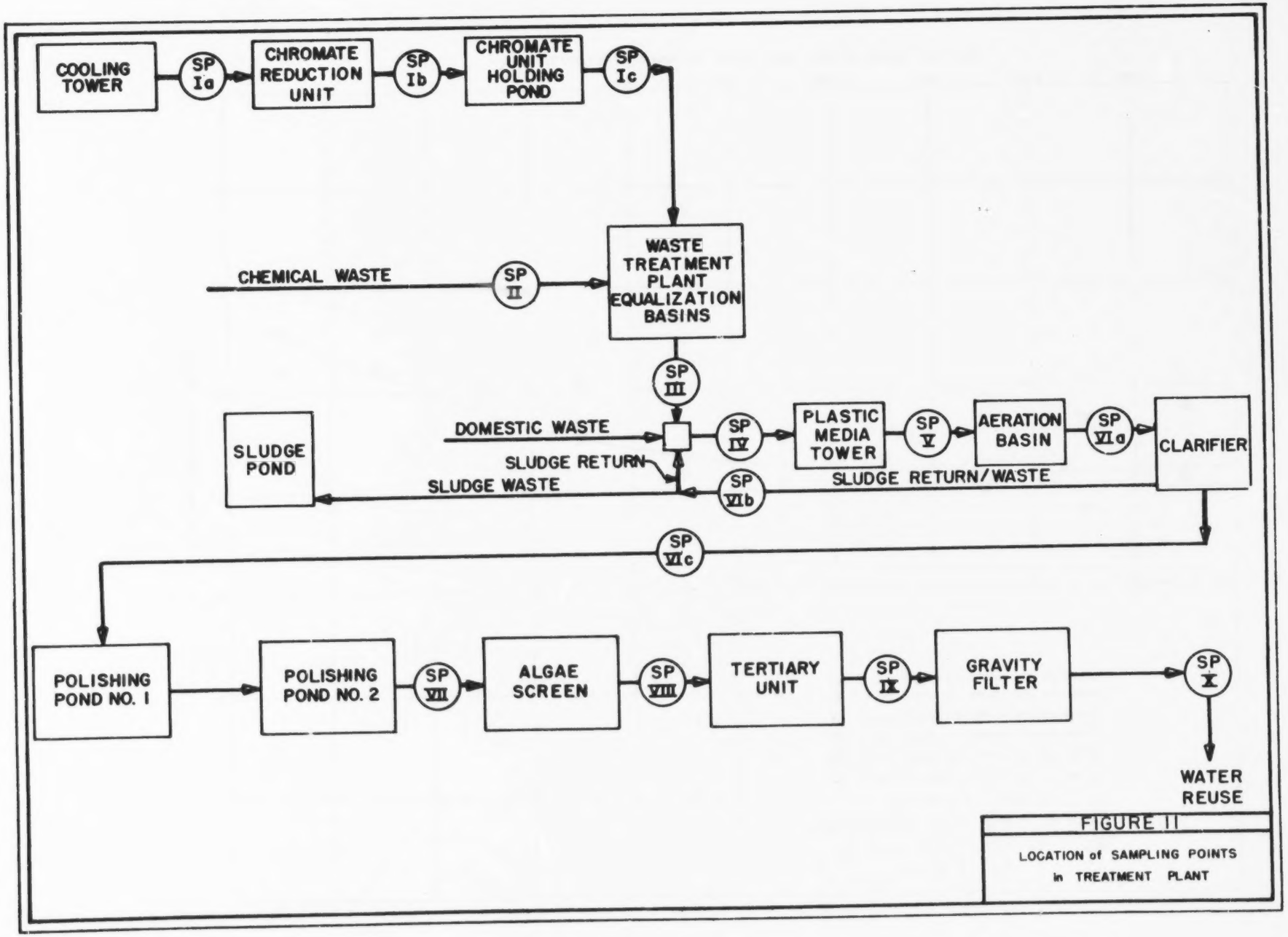


FIGURE II

LOCATION of SAMPLING POINTS in TREATMENT PLANT

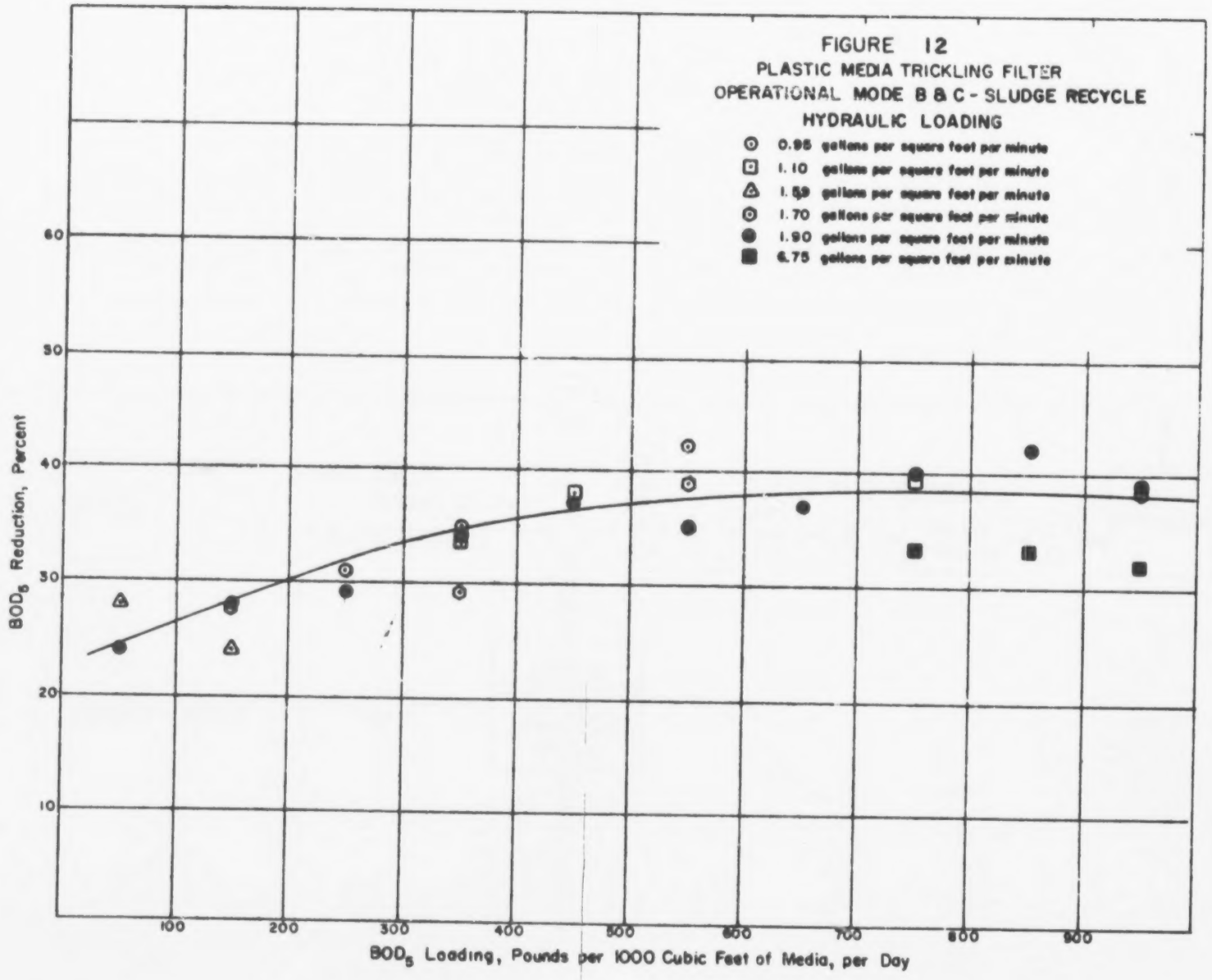


FIGURE 12
PLASTIC MEDIA TRICKLING FILTER
OPERATIONAL MODE B & C - SLUDGE RECYCLE
HYDRAULIC LOADING
0.95 gallons per square foot per minute
1.10 gallons per square foot per minute
1.59 gallons per square foot per minute
1.70 gallons per square foot per minute
1.90 gallons per square foot per minute
6.75 gallons per square foot per minute
BOD5 Reduction, Percent
10
20
30
40
50
60
100
200
300
400
500
600
700
800
900
BOD5 Loading, Pounds per 1000 Cubic Feet of Media, per Day

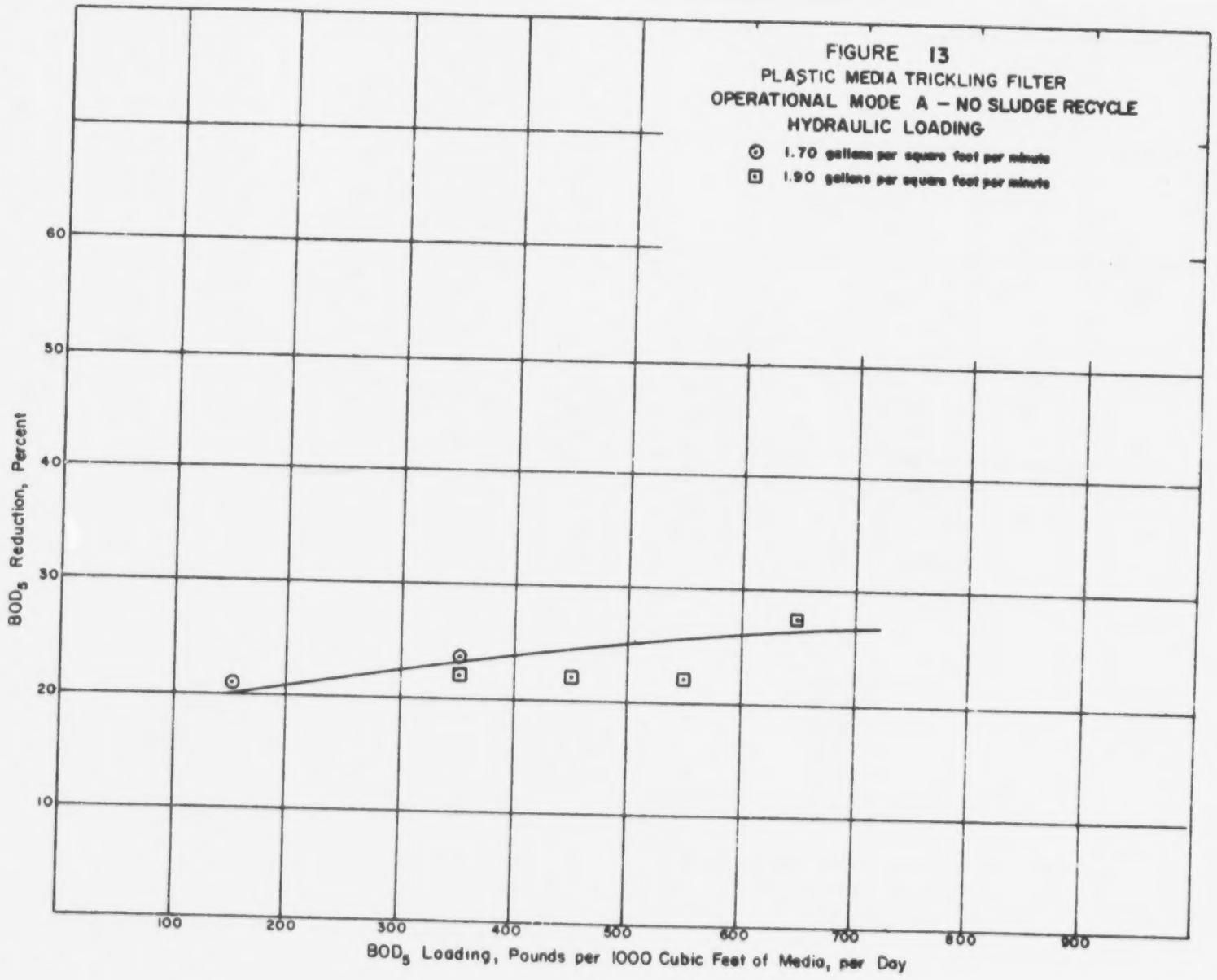


FIGURE 13
PLASTIC MEDIA TRICKLING FILTER
OPERATIONAL MODE A – NO SLUDGE RECYCLE
HYDRAULIC LOADING
1.70 gallons per square foot per minute
1.90 gallons per square foot per minute
BOD5 Reduction, Percent
10
20
30
40
50
60
100
200
300
400
500
600
700
800
900
BOD5 Loading, Pounds per 1000 Cubic Feet of Media, per Day

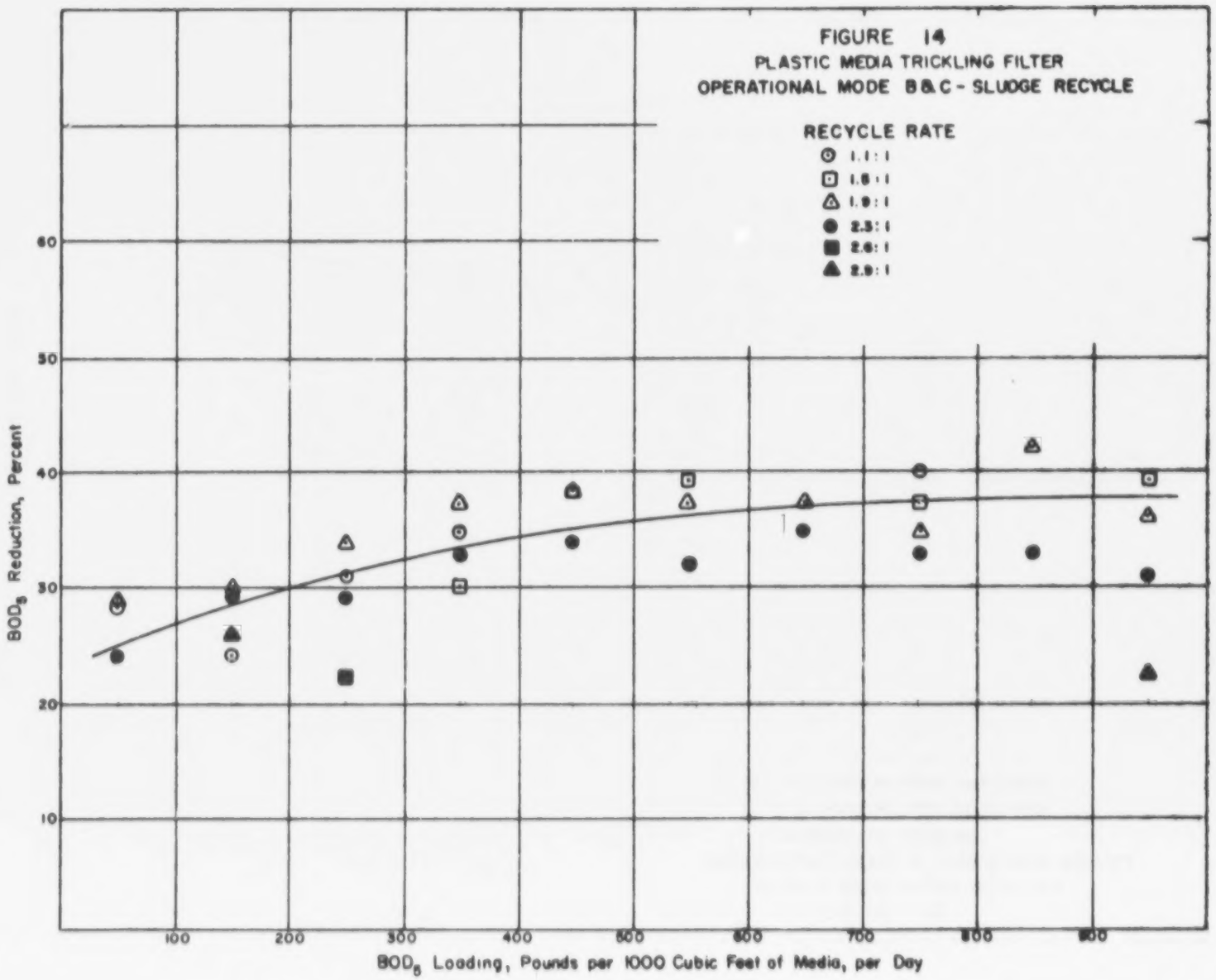


FIGURE 14
PLASTIC MEDIA TRICKLING FILTER
OPERATIONAL MODE B&C - SLUDGE RECYCLE
RECYCLE RATE
1.1 : 1
1.8 : 1
1.9 : 1
2.3 : 1
2.6 : 1
2.9 : 1
BOD5 Reduction, Percent
60
50
40
30
20
10
100
200
300
400
500
600
700
800
900
BOD5 Loading, Pounds per 1000 Cubic Feet of Media, per Day

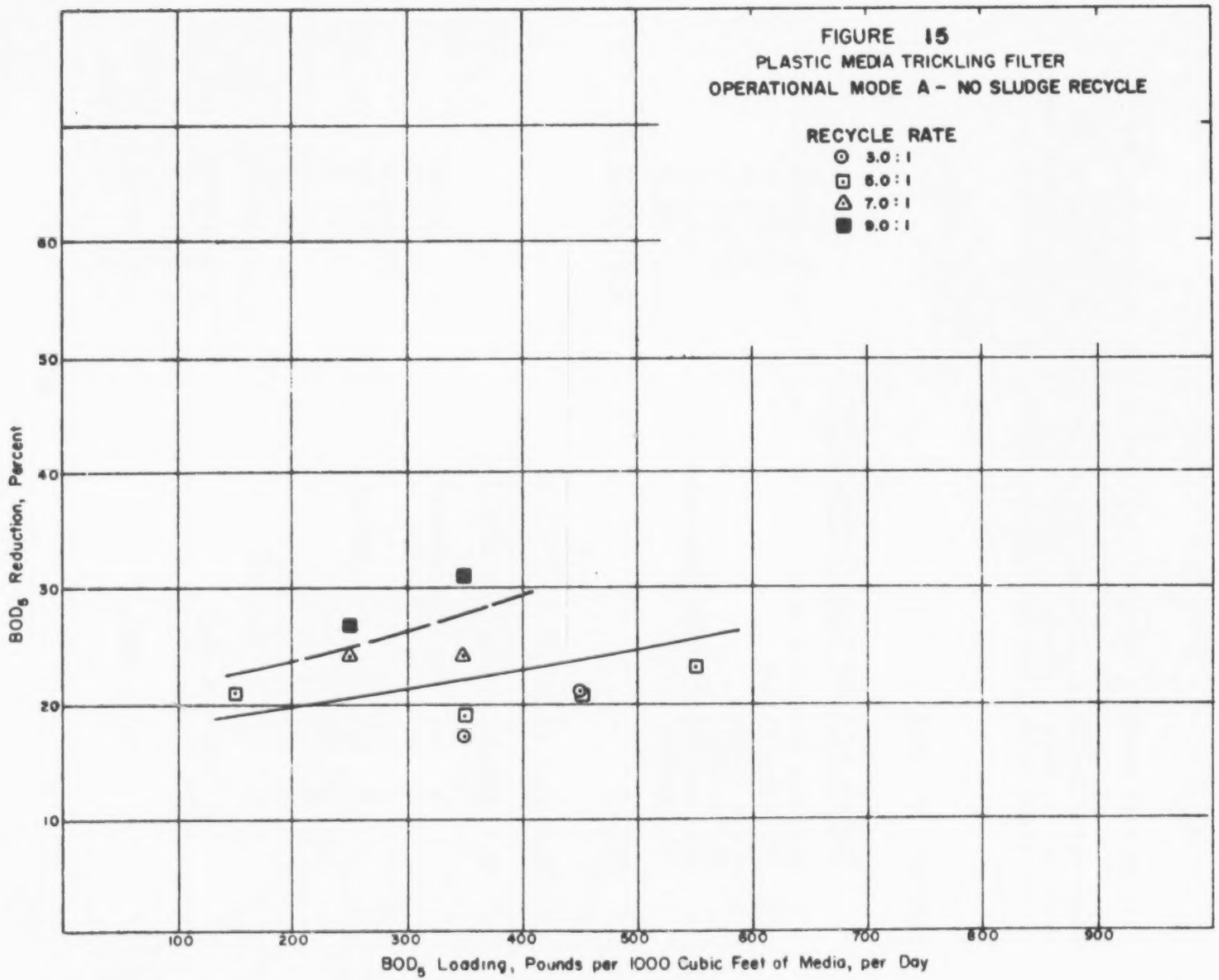


FIGURE 15
PLASTIC MEDIA TRICKLING FILTER
OPERATIONAL MODE A - NO SLUDGE RECYCLE
RECYCLE RATE
3.0 : 1
6.0 : 1
7.0 : 1
9.0 : 1
BOD5 Reduction, Percent
60
50
40
30
20
10
100
200
300
400
500
600
700
800
900
BOD5 Loading, Pounds per 1000 Cubic Feet of Media, per Day

ECONOMIC EVALUATION

This section contains selected cost data on the construction and operation of the waste treatment facility during the grant. The waste water treatment plant as constructed, but not including the grant units, cost in excess of $600,000. The cost of construction of the grant units (1968 basis) is summarized on a unit basis as follows:

Construction Costs

A. Summary of Final Construction Costs

Chromate Reduction Unit	$ 39,410.26
Trickling Filter	57,029.80
Algae Screen	16,378.47
Carbon Unit	56,010.44
Site and Distribution Requirements	10,542.03
Engineering	19,136.65
TOTALS	$198,507.65

B. Unit Cost Details

1. Chromate Reduction Unit

a.	Building Foundations	$ 585.00
b.	Building Structure	8,110.00
c.	Equipment	21,863.00
d.	Equipment Foundations	325.00
e.	Electrical	4,004.26
f.	Piping	2,903.00
g.	Paving (Gravel)	250.00
h.	Grading (Lagoon)	1,370.00
	Direct Cost	$ 39,410.26
	Engineering & Site Allocation	6,927.00
	TOTAL COST	$ 46,337.26

2. Trickling Filter

a.	Equipment	$27,000.00
b.	Equipment Foundations	15,470.00
c.	Painting	705.00
d.	Electrical	2,730.00
e.	Piping	11,124.80
	Direct Cost	$57,029.80
	Engineering & Site Allocation	10,025.46
	TOTAL COST	$67,055.26

3. Algae Screen

a.	Equipment	$10,140.68
b.	Equipment Foundations	2,040.00
c.	Electrical	475.00
d.	Piping	3,722.79
	Direct Cost	$16,378.47
	Engineering & Site Allocation	2,878.83
	TOTAL COST	$19,257.30

4. Carbon Unit

a.	Building Structure	$ 1,804.00
b.	Equipment	42,670.03
c.	Equipment Foundations	3,081.00
d.	Electrical	911.16
e.	Piping	6,142.65
f.	Grading (Lagoon)	1,401.60
	Direct Cost	$56,010.44
	Engineering & Site Allocation	9,847.39
	TOTAL COST	$65,857.83

5. Site and Distribution

a.	Electrical	$ 4,521.91
b.	Piping	5,112.75
c.	Paving (Gravel)	907.37
TOTAL COST		$10,542.03

6. General Requirements (Overheads)

a.	Preliminary Plans and Specifications	$ 3,995.76
b.	Final Plans and Specifications	8,825.00
c.	Construction Super.	6,315.89
TOTAL COST		$19,136.65

NOTE: Miscellaneous piping changes were made during the experimental portion of the grant for evaluation purposes. These costs are not included above since they could be considered duplication.

Selected Comparative Costs Including Operating Costs

Some selected comparative cost, including operating costs for the treatment plant and grant units under selected conditions, are as follows:

1. Cost of treatment plant operation before grant (1967) — $0.35/1000 gallons of waste treated

   This includes electricity, maintenance, operator salary and all other operation and maintenance costs. No capital costs are included.

2. Cost of treatment plant operation during grant period — $0.64/1000 gallons of waste treated

   This includes all items in 1 above in addition to extra operating personnel required by the grant experimental phase, additional electrical requirements, chemicals and flocculants. It does not include the mobile laboratory operation.

3. Estimated cost of treatment plant operation in the future utilizing selected grant units on a production basis as compared to experimental basis in 2 above. — $0.40/1000 gallons of waste treated

   This includes the operation of the trickling filter, microscreen and a greatly reduced operation of the chemical treatment unit in line with the findings of this project.

4. The average market value of polyester produced in the Fiber Industries, Inc., Shelby plant during the grant period was $0.88 per pound. During this period 0.604 gallons of waste containing 0.0056 pounds of BOD_5 was produced per pound of polyester produced. The cost of treatment of the waste from the production of one pound of polyester, using item 2 above as a basis, is $0.00039. This is the operational cost and does not include any capital cost considerations.

5. The chromate reduction unit chemical costs are based on the chemicals required to treat one pound of chromate. The theoretical and actual costs are as follows:

Theoretical cost per pound of CrO_4 =

0.85 pounds SO_2	@ 0.075	=	$0.064
0.30 pounds H_2SO_4	@ 0.027	=	0.008
1.10 pounds NaOH	@ 0.060	=	0.066
TOTAL THEORETICAL COST			$0.138

In actual operation about 50 percent excess chemicals are required to assure complete reaction. The actual cost of treating one pound of CrO4 =

Actual Total Cost = 0.138 x 1.5 = $0.21

6. The chemical and/or flocculant costs must be based on the water quality desired and the flocculant selected for use. A typical cost for chemical post treatment at the Fiber Industries, Inc., Shelby operation is as follows:

		Cost per 1000 gallons
Aqua Rid 49-701	13 mg/l	$0.022
Aqua Rid 96-549	30 mg/l	0.025
		$0.047

7. The cost of the plastic media trickling filter unit as compared to an equivalent mechanical aeration unit may be derived by comparing the tower, complete with pump and sump, with a single 75 HP aerator installation complete.

Plastic media trickling filter (see Items 1, 5 and 6, above)

Construction Contract	$57,029.80
Prorated site, distribution and General Requirements	10,025.46
	$67,055.26

Mechanical Aerator Installation

Aerator	$17,000.00
Platform and Miscellaneous Structures	6,500.00
Electrical	6,000.00
Basin	30,000.00
Prorated site and distribution	2,000.00
Prorated general requirements	4,000.00
	$65,500.00

SECTION VII

OPERATION OF THE TREATMENT SYSTEM ON A PRODUCTION BASIS

The waste treatment system can be operated on a full scale basis with water reuse at 0.1 MGD using the following treatment units at the below listed estimated costs:

Pre Treatment	
Chromate Reduction and Equalization	$0.034 / 1000 gallons
Primary and Secondary Treatment	
Roughing Filter	0.019 / 1000 gallons
Aeration and Clarification	0.300 / 1000 gallons
Tertiary Treatment	
Polymer Addition and Final Filter	0.047 / 1000 gallons
ESTIMATED TOTAL OPERATING COST	$0.400 / 1000 gallons

The estimated total capital cost for such a treatment facility, using design criteria contained in Section V of this report, is $800,000 (1968 basis).

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SECTION VIII

ACKNOWLEDGEMENTS

The support of Mr. J. B. Phelps, Vice President and Mr. Richard Shalie, Director of Engineering of Fiber Industries, Incorporated is acknowledged with sincere thanks.

Mr. W. J. Day and Mr. E. C. Burrell of Davis & Floyd, Inc., Consulting Engineers, directed the design and operation of the Grant and prepared this report. Mr. C. E. Steinmetz, Engineering Associate, Fiber Industries, Incorporated, functioned as Project Coordinator on this project.

The support of the project by the Federal Water Quality Administration and the timely guidance of Dr. Ray Thacker, Mr. William Lacy and Mr. Charles Ris is acknowledged.

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SECTION X

APPENDIX I

LABORATORY ANALYTICAL PROCEDURES

The basic analytical procedures used for the determination of Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), dissolved oxygen (DO), pH, solids, nitrogen, phosphorus, temperature, color, turbidity, alkalinity, hardness, sulfate, chloride, were taken from Standard Methods for the Examination of Water and Wastewater, Twelfth Edition, American Public Health Association, Inc., New York. Secondary procedures and reagents used for these same determinations were taken from Methods Manual, Fifth Edition, Hach Chemical Company, Ames, Iowa. Special procedures for determinations not contained in Standard Methods were as follows:

Chromium (Total, Hexavalent, Trivalent)

Total chromium - A Beckman Atomic Absorption system Model 930 utilizing a Beckman DB-G Grating Spectrophotometer was used for this determination. The procedure was in accordance with Beckman Instruments, Inc., Flame Notes, Vol. 1, No. 2, July 1966, pages 49 and 50.

Hexavalent chromium - this procedure was taken from Standard Methods for the Examination of Water and Wastewater, Twelfth Edition, American Public Health Association, Inc., New York, pages 123 and 124.

Coagulation - Flocculation Jar Test

This procedure used for flocculation jar tests is presented in Part 23, Industrial Water; Atmospheric Analysis, American Society for Testing and Materials, Philadelphia, Pa., (1967), pages 523 - 525.

Zinc

A Beckman Atomic Absorption system Model 979 utilizing a Beckman DB-G Grating Spectrophotometer was used for this determination. The procedure was in accordance with Beckman Instruments, Inc., Flame Notes, Vol. 1, No. 3, September 1966, page 91.

Determination of Sodium Pentachlorophenates (Betz A-9) in Water

This procedure was furnished by Betz Laboratories and is a colormetric analysis for sodium pentachlorophenate through an extraction and color development.

A representative 5 ml. sample is pipetted into a 125 ml. separator funnel. To this is added 10 ml. of ethylene dichloride. Immediately add 0.25 grams of sodium bicarbonate and 0.5 ml. safranine "A" reagent (Matheson Coleman & Bell). Proceed to shake for 30 seconds and allow to stand for one minute. Draw off the bottom layer into a 100 ml. beaker and add 0.25 to 1.00 grams sodium sulfate while swirling the sample after the addition of each 0.25 grams portion until the solution is crystal clear. Transfer the solution to a cell and with the use of a spectrophotometer read percent transmission. Ethylene dichloride is used in a cell to establish the zero reference point.

Determination of Methyl and Ethyl Bis-dilthiocarbamate (Betz C-34) in Water

This method was also furnished by Betz Laboratories. It is based on the fact that methyl and ethyl bis-dithiocarbamate decomposes to liberate carbon disulfide when boiled in sulfuric acid. The gas is then swept through several scrubbers to remove interferences and then through a scrubber containing Viles reagent (a copper amino solution). The intensity of the color resulting from the reaction between the carbon disulfide and Viles reagent is used to quantitate the amount of active carbamates present.

A. Reagents and Equipment.

1. Methanolic Potassium Hydroxide 2N
2. Lead Acetate Solution 10%
3. Sulfuric Acid 50%
4. Viles Reagent - In a liter flask containing 50 ml. distilled water add 0.060 gram of reagent grade copper acetate monohydrate, followed by 20 ml. USP triethanol amine and 10 ml. of purified diethylamine. Dilute to the 1 liter mark with reagent grade isopropanol and mix. Store in a well capped amber bottle.
5. Copper Acetate Monohydrate - reagent grade
6. Triethanol Amine - USP
7. Diethylamine - purified

8. Isopropanol - reagent grade

9. Absorption Train - as illustrated in sketch - all joints must be ground glass

10. Spectrophotometer or Colorimeter - capable of isolating a reasonably small wavelength band at 420 nanometers

11. Stock C-34 Solution - pipet 1.0 ml. of C-34 into a 1 liter volumetric flask and dilute to 1 liter with distilled water.

12. Standard C-34 Solution - pipet 2.0 ml. of the stock solution into a 1 liter volumetric flask and dilute to 1 liter with distilled water.

B. Sample Procedure.

1. Add 10 ml. of Viles reagent to the carbon disulfide scrubber, 20 ml. lead acetate solution to each hydrogen sulfide scrubber and 65 ml. of methanolic potassium hydroxide to the air scrubber.

2. Turn on the condenser water.

3. Add 1 liter of test sample to the reaction flask followed by 100 ml. of the 50% sulfuric acid.

4. Immediately fasten the flask to the condenser, close all connections, and start the air flow through the system at a rate of approximately 40 ml. per minute.

5. Turn on the heating mantle and bring the sample to a gentle boil.

6. Reflux (with continual air sweep) for one hour.

7. Discontinue heating and open the connections in the following order to avoid "back-up". (a) inlet to reaction flask; (b) inlet to lead acetate scrubbers; (c) inlet to carbon disulfide scrubber containing the Viles reagent.

8. Shut off the air sweep and remove the graduated carbon disulfide scrubber containing the Viles reagent.

9. Make up the volume of the Viles reagent to 10 ml. with isopropanol.

10. Transfer solution to a 1 cm. or equivalent cell and read the color intensity at 420 nanometers. Use isopropanol for the 100% T setting.

11. Carry 1 liter of distilled water through the above steps. This will be used as the reagent blank.

12. Subtract the absorbance of the reagent blank and read the concentration of the C-34 from the standard curve.

C. Preparation of the Standard Curve.

1. Pipet into clean beakers 0 (reagent blank), 10, 25, 50, 75, 100 ml. of the standard C-34 solution. This represents 0, 0, 20, 0.50, 1.00, 1.50 and 2.00 parts per million of the biocide.

2. Transfer each sample, in turn, to a 1-1/2 liter round bottom flask and dilute to one liter with distilled water.

3. Continue on, starting with step (1) through step (7) under "Sample Procedure".

4. Subtract the absorbence of the reagent blank from each reading.

5. Plot absorbence against PPM C-34.

D. Calculations.

1. If 1000 ml. sample
   PPM C-34 = PPM C-34 read from standard curve

2. If sample volume other than 1000 ml.

$$\text{PPM C-34} = \frac{(\text{PPM C-34 from standard curve})(1000)}{(\text{Sample volume in mls.})}$$

Determination of Methylene Bis Thiocyanate (Betz C-30) in Water

Methylene bis-thiocyanate (Betz C-30) is converted to cyanide and thiocyanate by an alkaline hydrolysis. After suitable sample cleanup the cyanide and thiocyanate are converted to their respective bromide compounds, reacted with a pyridine - benzidine reagent and the color read at 532 nm. The intensity of the red color is an indirect measure of the amount of methylene bis-thiocyanate present in the paper. This procedure was also provided by Betz Laboratories.

A. Reagents and Equipment.

1. Arsenous acid - a 2.0% solution of arsenous acid is prepared by refluxing 2.0 gms of arsenous acid with distilled water until disolution is complete. It is then diluted to 100 ml.

2. Bromine water - a standard solution of bromine distilled water.

3. Pyridine solution - a solution is prepared by adding 100 ml. of concentrated hydrochloric acid to 1 liter of 60% pyridine in water (v/w).

4. Trichloroacetic acid - a solution of 20% trichloroacetic (w/v) in distilled water.

5. Benzidine De-Hydrochloride - reagent grade.

6. Pyridine-Benzidine Reagent - 0.2 grams of benzidine dihydrochloride in 5 ml. of distilled water is added to 25 ml. of pyridine reagent. This solution must be prepared fresh daily.

7. Stock "Standard Methylene Bis-Thiocyanate Solution" - 0.200 gram of Stauffer N-948 is hydrolyzed for 60 minutes in 5 ml. of 20% NaOH at room temperature. The solution is then filtered into a 1 liter volumetric flask and the filter paper is washed several times with 0.10 M NaOH. Dilute to 1 liter with distilled water.

8. "Standard Methylene Bis-Thiocyanate Solution" - 10 mls. of stock solution is diluted to 1 liter with distilled water. This solution contains a 2 micrograms of M-bis-Thiocyanate per milliliter.

9. Pyridine - reagent grade.

10. 0.10 M Sodium Hydroxide (NaOH) - Betz Code 206 or equivalent.

11. Sodium Hydroxide Solution 20% - dilute 20 gms of NaOH to 100 ml. with distilled water.

12. Hydrochloric acid - reagent grade.

13. n-Amyl Alcohol - reagent grade.

14. Filter paper - Munktell's 00 or equivalent.

15. 10 ml. Volumetric flasks.

16. 125 ml. separatory funnels.

17. Spectrophotometer or colorimeter - capable of isolating a reasonably small wavelength band at 532 manometers.

B. Sample Procedure.

1. To 50 ml. of sample add 10 ml. of 0.1 NaOH and hydrolyze at room temperature for one hour. The sample should be strongly alkaline prior to hydrolysis - if not add more 0.1 M NaOH until strongly basic, i.e., pH 12.

2. Filter the sample thru a Munktell 00 filter paper washing the paper two times with distilled water.

3. Add 5 ml. of trichloroacetic acid followed by 3 ml. of bromine water to the filtrate.

4. Swirl the beaker contents for one minute.

5. Add 3 ml. of the arseneous acid to discharge the bromine color. Blow off any vapors of bromine above the solution.

6. Quantitatively transfer the contents to a clean 125 ml. separatory funnel and add 5 ml. of pyridine-benzide reagent. Shake well and let sit 1/2 hour.

7. Add 5 ml. of n-amyl alcohol and shake well.

8. When the phases separate drain the upper alcohol layer through a glass wool plug into a 10 ml. volumetric flask. Rinse the funnel several times with small portions of alcohol.

9. Dilute to make with alcohol and read the color intensity at 532 nanometers. Use distilled water for the 100% T setting.

10. Carry 50 ml. of the water sample through the above steps omitting the hydrolysis step. This will be used as the reagent - sample blank.

11. Subtract the absorbance of the reagent - sample blank and read the concentration of the M-bis-Thiocyanate from the standard curve.

C. Preparation of the Standard Curve.

1. Pipet into clean 100 ml. beakers 0 (reagent blank), 1, 2, 3, 4, and 5 ml. of the standard methylene bis-thiocyanate solution. This is equivalent to 0, 2, 4, 6, 8, and 10 micrograms of biocide.

2. Add 5 ml. of the 0.1 M NaOH solution to each.

3. Continue on, starting with step (3) through (14) under "Sample Procedure".

4. Subtract the absorbence of the reagent blank from each reading.

5. Plot absorbence against micrograms of methylene bis-thiocyanate.

D. Calculations.

$$\text{PPM MBT in water} = \frac{\text{micrograms MBT read off of std. curve}}{\text{milliliters of sample}}$$

$$\text{PPM C-30* in Water} = \frac{\text{PPM MBT}}{.05}$$

* assuming C-30 contains 5% methylene bis-thiocyanate

E. Comments.

All operations should be carried out under a hood. None of the concentrated methylene bis-thiocyanate solutions should come in contact with acids. All solutions should be pipetted using a rubber bulb, never by mouth. Both cyanide and arsenous acid solutions are very poisonous and extreme care should be exercised when handling.

Larger samples can be used simply by evaporating the sample to approximately 50 mls. only after make the solution basic to litmus with 0.1 N NaOH.

Determination of N-Alkyl Dimethyl Benzyl Ammonium Chloride (Betz J-12) in Water

A complete analytical method for J-12 is not available. However, an atomic absorption method for tin in tributyl tin oxide was used and this was related the N-alkyl dimethyl benzyl ammonium chloride. See appendix II for product description and proportion of tributyl tin in J-12.

To a 50 ml. sample add with stiring, 20 ml. perchloric-sulfuric mixture; this is to destroy any organic matter which may be present. Allow to stand for 5 minutes and then extract this solution with 50 ml. of chloroform. The analysis may now be completed on the extracted portion using the atomic absorption method and procedures of the Beckman Instrument Company.

APPENDIX II

IDENTIFICATION OF TRADE NAME PRODUCTS

BIOCIDES

1. Betz A-9.

Sodium pentachlorophenate	24.7%
Sodium 2, 4, 5-trichlorophenate	9.1%
Sodium salts of other chlorophenates	2.9%
Sodium dimethyl dithiocarbamate	4.0%
N-Alkyl (C_{12}-4%, C_{14}-50%, C_{16}-10% dimethyl benzyl ammonium chloride	5.0%
Inert ingredients (including solubilizing and dispersing agents)	54.3%

2. Betz C-5.

1, 3, dichloro-5, 5-dimethylhydantoin	50 %
Inert ingredients (including solubilizing and dispersing agents)	50 %

3. Betz C-30.

Bis (trichloromethyl) sulfone	20.0%
Methylene bisthiocyanate	5.0%
Inert ingredients (including solubilizing and dispersing agents)	75.0%

4. Betz C-34.

Sodium dimethyl dithiocarbamate	15.0%
Nabam(disodium ethylene bisdithiocarbamate)	15.3%
Inert Ingredients (including solubilizing and dispersing agents)	69.7%

5. Betz J-12.

N-Alkyl (C_{12}-5%, C_{14}-60%, C_{16}-30%, C_{18}-5%) dimethyl benzyl ammonium chloride	24.0%
Bis (tributyltin) oxide	5.0%
Inert Ingredients (including solubilizing and dispersing agents)	71.0%

FLOCCULANTS

1. Coagulant Aid 25 - A pulverized clay, off white in color.
   Calgon Corporation, Pittsburgh, Pa.

2. Coagulant Aid 27 - A tan pulverized clay.
   Calgon Corporation, Pittsburgh, Pa.

3. Coagulant Aid 225 - A cationic polyelectrolyte.
   Calgon Corporation, Pittsburgh, Pa.

4. Coagulant Aid 226 - A cationic polyelectrolyte.
   Calgon Corporation, Pittsburgh, Pa.

5. Coagulant Aid 227 - A slightly cationic polyelectrolyte.
   Calgon Corporation, Pittsburgh, Pa.

6. Coagulant Aid 228 - A slightly cationic polyelectrolyte.
   Calgon Corporation, Pittsburgh, Pa.

7. Cat-Floc - A cationic polyelectrolyte.
   Calgon Corporation, Pittsburgh, Pa.

8. Primafloc A-10 - An anionic polyelectrolyte.
   Rohm and Haas Company, Philadelphia, Pa.

9. Primafloc C-3 - A polyamine cationic polyelectrolyte.
   Rohm and Haas Company, Philadelphia, Pa.

10. Primafloc C-5 - A polyamine cationic polyelectrolyte.
    Rohm and Haas Company, Philadelphia, Pa.

11. Primafloc C-7 - A cationic polyamine bisulfate polyelectrolyte.
    Rohm and Haas Company, Philadelphia, Pa.

12. Aqua-Rid 49-700 - A cationic polyamine polyelectrolyte.
    Reichhold Chemicals, Inc., Tuscaloosa, Ala.

13. Aqua-Rid 49-702 - A polyamine polyelectrolyte.
    Reichhold Chemicals, Inc., Tuscaloosa, Ala.

14. Aqua-Rid 49-703 - A anionic poly-aromatic polyelectrolyte.
    Reichhold Chemicals, Inc., Tuscaloosa, Ala.

15. Aqua-Rid 49-701 - A cationic polyamine polyelectrolyte.
    Reichhold Chemicals, Inc., Tuscaloosa, Ala.

16. Aqua-Rid 96-549 - A correctant and catalyst for use with
    49-701, 49-702, 49-703, or 49-700 Aqua Rids.
    Reichhold Chemicals, Inc., Tuscaloosa, Ala.

17. Natron 86 - A cationic polyelectrolyte.
National Starch and Chemicals Corporation, New York, N. Y.

18. Resyn 3285 - A anionic polyelectrolyte.
National Starch and Chemical Corporation, New York, N. Y.

19. Poly-Floc 1160 - A copolymer of acrylamide.
Betz Laboratories, Inc., Treuose, Pa.

20. Magnifloc 900-N - A nonionic polyacrylamide.
American Cyanamid Company, Wayne, New Jersey.

21. Magnifloc 905-N - A nonionic polyacrylamide.
American Cyanamid Company. Wayne, New Jersey.

22. Magnifloc 865-A - A anionic polyacrylamide.
American Cyanamid Company, Wayne, New Jersey.

23. Aluminum Sulfate.
Allied Chemical Corporation.

CARBON

1. Aqua Nuchar "A"
West Virginia Pulp and Paper Company, New York, N. Y.

2. Darco S-51.
Atlas Chemical Industries, Inc., Wilmington, Delaware.

BIBLIOGRAPHIC:

Fiber Industries, Incorporated, Reuse of Chemical Fiber Plant Wastewater and Cooling Water Blowdown, Final Report FWQA Grant No. 12090 EUX 10/70.

ABSTRACT:

Demonstration studies were conducted to determine the feasibility of reusing industrial and domestic wastewaters from a FORTREL Polyester manufacturing plant. The wastewaters consisted of organic chemical process wastes, cooling system blowdown and domestic wastewaters from the plant. Selected unit processes and operations were superimposed on an existing activated sludge system in an effort to improve the quality of the treated discharge. The cooling system blowdown was pretreated with sulfur dioxide in an acidic environment to remove chromium. The cooling water biocides which passed through the chromium reduction unit were observed for their possible effect on the biological treatment system. A plastic media trickling filter was evaluated for its effectiveness as a roughing filter ahead of an activated sludge unit. The effluent from the secondary treatment system was filtered through a microscreen, and treated with polymers and/or carbon to remove color, COD, dissolved and suspended solids.

The results of these studies indicate that chromium can be removed from the cooling tower blowdown for 21¢ per pound of chromate and that the type and concentration of biocides normally used in cooling water are either destroyed in the chromate reduction system or exhibit no adverse effect on the secondary and tertiary treatment system. The plastic media trickling filter, operated with a sludge recycle from the clarifier and reduced the BOD by 40%. The 0.33 mgd industrial and domestic wastewater can be treated and reused at a rate of 0.10 mgd for approximately 40¢/1000 gallons.

This report was submitted in fulfillment of project 12090 EUX under partial sponsorship of the Federal Water Quality Administration.

ACCESSION NO.

KEY WORDS:

Cooling Water
Chromium Reduction
Chemical Precipitation
Trickling Filters
Filtration
Tertiary Treatment
Water Reuse

BIBLIOGRAPHIC:

Fiber Industries, Incorporated, Reuse of Chemical Fiber Plant Wastewater and Cooling Water Blowdown, Final Report FWQA Grant No. 12090 EUX 10/70.

ABSTRACT:

Demonstration studies were conducted to determine the feasibility of reusing industrial and domestic wastewaters from a FORTREL Polyester manufacturing plant. The wastewaters consisted of organic chemical process wastes, cooling system blowdown and domestic wastewaters from the plant. Selected unit processes and operations were superimposed on an existing activated sludge system in an effort to improve the quality of the treated discharge. The cooling system blowdown was pretreated with sulfur dioxide in an acidic environment to remove chromium. The cooling water biocides which passed through the chromium reduction unit were observed for their possible effect on the biological treatment system. A plastic media trickling filter was evaluated for its effectiveness as a roughing filter ahead of an activated sludge unit. The effluent from the secondary treatment system was filtered through a microscreen, and treated with polymers and/or carbon to remove color, COD, dissolved and suspended solids.

The results of these studies indicate that chromium can be removed from the cooling tower blowdown for 21¢ per pound of chromate and that the type and concentration of biocides normally used in cooling water are either destroyed in the chromate reduction system or exhibit no adverse effect on the secondary and tertiary treatment system. The plastic media trickling filter, operated with a sludge recycle from the clarifier and reduced the BOD by 40%. The 0.33 mgd industrial and domestic wastewater can be treated and reused at a rate of 0.10 mgd for approximately 40¢/1000 gallons.

This report was submitted in fulfillment of project 12090 EUX under partial sponsorship of the Federal Water Quality Administration.

ACCESSION NO.

KEY WORDS:

Cooling Water
Chromium Reduction
Chemical Precipitation
Trickling Filters
Filtration
Tertiary Treatment
Water Reuse

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1 Accession Number	2 Subject Field & Group	SELECTED WATER RESOURCES ABSTRACTS INPUT TRANSACTION FORM
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5 Organization

Fiber Industries, Incorporated
P. O. Box 10038
Charlotte, North Carolina 28201

6 Title

Reuse of Chemical Fiber Plant
wastewater and cooling water blowdown

10 Author(s)

William J. Day

16 Project Designation

FWQA 12090 EUX

21 Note

In conjunction with:
Davis & Floyd Engineers, Inc.
Greenwood, South Carolina

22 Citation

23 Descriptors (Starred First)

Cooling water
Chromium
Chemical Reduction
Chemical Precipitation
Trickling Filters
Tertiary Treatment
Filtration
Water Reuse

25 Identifiers (Starred First)

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Abstractor W. J. Day | Institution Davis & Floyd Engineers, Inc.

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